The strategies to enable, and challenges faced with implementation of quality electronic health records in South Africa

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Candidate:

Campion Zharima

Student number:

783436

Supervisors:

Professor Jane Goudge and Professor Frances Griffiths

Declaration

I, Campion Zharima, declare that the work contained in this thesis is my own work and it is being submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Public Health at the School of Public Health, Faculty of Health Sciences at the University of the Witwatersrand. This thesis has not been submitted elsewhere before for examination or towards the fulfilment of any other degree.

I also acknowledge that plagiarism is unethical and would like to confirm that my thesis contains original and independent work, except where it is stated otherwise. I am familiar with the guidelines on referencing and plagiarism as outlined in the Wits Plagiarism policy and I have adhered to them in the production of this work. I am thus aware that the University of the Witwatersrand may impose disciplinary measures such as suspension or expulsion if it is found that this work does not adequately adhere to these guidelines.

Student signature

Date of submission

07 October 2025

Dedication

I dedicate this work to all the efforts of the advancement of digital health and its transformative potential in strengthening health systems. May this work contribute to the effort of all the researchers, policymakers, and healthcare professionals who are working tirelessly to integrate technology into healthcare. Above all, may it drive innovation and improve lives.

Publications from this PhD

This PhD contributed to the development and publication of three research articles, which are detailed in this thesis. The citations for these publications are as follows:

1. **Zharima, C.,** Griffiths, F., & Goudge, J. (2023). Exploring the barriers and facilitators to implementing electronic health records in a middle-income country: a qualitative study from South Africa. *Frontiers in Digital Health*, *5*, 1207602. https://doi.org/10.3389/fdgth.2023.1207602

2. **Zharima, C.**, Mhlanga, S., Abdulla, S., Goudge, J., & Griffiths, F. (2024). What engagement strategies are useful in facilitating the implementation of electronic health records in health care settings? A rapid review of qualitative evidence synthesis using the normalization process theory. *Digital Health*, *10*, 20552076241291286. https://doi.org/10.1177/20552076241291286

3. **Zharima, C.**, Griffiths, F., & Goudge, J. (n.d.). Exploring the factors associated with the stalled implementation of a ground-up EHR system in South Africa: Insights from the E-Tick case study using the Consolidated Framework for Implementation Research (CFIR).

Other publications during this PhD

1. **Zharima, C.**, Singh, R., Closson, K., Beksinska, M., Zulu, B., Jesson, J., Pakhomova, T., Dong, E., Dietrich, J., Kaida, A. and Basham, C.A. (2024). Economic hardship and perpetration of intimate partner violence by young men in South Africa during the COVID-19 pandemic (2021–2022): a cross-sectional study. Injury epidemiology, 11(1), 2.

2. Closson, K., **Zharima, C.**, Kuchena, M., Dietrich, J.J., Gadermann, A., Zulu, B., Ogilvie, G., Beksinska, M. and Kaida, A. (2024). "It's a 50/50 Thing You Know": Exploring the Multileveled Intersections of Gender and Power Within the Relationships of Young South African Men and Women. The Journal of Sex Research, 61(1), 144-159.

3. Mhlanga, S., Griffiths, F., **Zharima, C.**, Robertson, L., Abdulla, S., & Goudge, J. (2024). Service Users' and Providers' Experiences and Perceptions of Mental Health

Accommodation Services: A Rapid Qualitative Synthesis of International Evidence. *Health & Social Care in the Community*, *2024*(1), 7971386.

4. Chenneville, T., Gabbidon, K., **Zharima, C.**, Hornschuh, S., & Dietrich, J. J. (2023). Factors affecting COVID-19's mental health impact on college students in the southeastern United States. *Frontiers in Public Health*, *11*, 1225686.

Conference presentations from this PhD

1. **Zharima, C.,** Griffiths, F., & Goudge, J. (2023). Exploring the barriers and facilitators to implementing electronic health records in a middle-income country: a qualitative study from South Africa. *Frontiers in Digital Health*, *5*, 1207602. **Oral presentation at the South African Public Health Association of South Africa (PHASA) conference from 10 - 13 September 2023 held in East London.**

2. **Zharima, C.,** Griffiths, F., & Goudge, J. (2023). Exploring the barriers and facilitators to implementing electronic health records in a middle-income country: a qualitative study from South Africa. *Frontiers in Digital Health*, *5*, 1207602. **Oral presentation at the Wits School of Public Health Biennial Research Day on 14 and 15 September 2023.**

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Acronyms and abbreviations

Acronym	Full description
CFIR	Consolidated Framework for Implementation Research
CHC	Community Health Care
CSIR	Council for Scientific and Industrial Research
DHIS	District Health Information Software
DHMIS	District Health Management Information System
DoH	Department of Health
EHR(s)	Electronic Health Record(s)
e-Health	Electronic health (a broad term used to describe the use of information and communications technologies in healthcare)
e-tick	Electronic tick (digital version of a patient tick register)
HIC	High Income Country
HPRS	Health Patient Registration System
IT	Information Technology
LMIC	Low to Middle Income Countries
MRC	Medical Research Council
NDoH	National Department of Health
NHI	National Health Insurance
NPT	Normalization Process Theory
PHC	Primary Health Care
TB	Tuberculosis
UHC	Universal Health Coverage
WHO	World Health Organization

Abstract

Background: As many middle-income countries move towards universal health coverage, the expansion of health care services using public funds has become more common. Electronic health records (EHRs) are critical for monitoring provider performance, enabling strategic purchasing and guiding the allocation of health care funds. South Africa, in its pursuit of the national health insurance (NHI), envisions EHRs as essential for informing purchasing decisions and tracking health outcomes. Despite the country's policy efforts, the progress in implementation of EHRs has been slow.

Primary aim: To examine the implementation challenges and identify potential strategies to ensure high quality EHRs in South Africa.

Methods: Data were collected between 2021 and 2023 using qualitative methods. At first, in-depth interviews were conducted with 18 key stakeholders, including academics, private sector managers, and government officials, to explore the barriers and facilitators of EHR implementation in South Africa. Secondly, 38 interviews were conducted with managers, implementers, and end-users to investigate the stalling of an electronic health record system, using the Consolidated Framework for Implementation Research (CFIR). Lastly, through a rapid review of global evidence examined 41 studies on EHR implementation to identify effective end-user engagement strategies for EHR adoption in healthcare settings, guided by the Normalization Process Theory (NPT). Thematic analysis was applied in all data sets.

Findings: Results revealed that while South Africa has a favorable policy landscape, the capacity and resources for a national EHR implementation, efforts have been hindered by leadership gaps, limited technical expertise, and insufficient investment in necessary infrastructure. However, the Western Cape, a province of South Africa, demonstrated significant progress, having developed a functioning EHR system through efforts spanning over two decades.

A case study of a piloted EHR system further revealed some of the factors and complexities of implementation in South Africa. In this case, while the system initially showed promise, supported by strong stakeholder engagement and consultative development, it eventually stalled due to external factors such as changes in developers, funding cuts and lack of provincial support.

Moreover, political interference in key appointments led to corruption and mismanagement of funds, further highlighting how contextual and systemic barriers can undermine a well-designed and adopted system.

Lastly, the review also identified effective user engagement strategies for successful user adoption, which include early user involvement, tailored training, and continuous technical support. Moreover, the successful adoption of EHRs is best achieved when engagement strategies aligned with NPT principles of coherence, cognitive participation, collective action, and reflexive monitoring. These principles guide implementers in ensuring that users understand the purpose of the system, actively engage in learning how to use it, collaborate and continuously contribute to improving it.

Conclusion: This study identified the multifaceted barriers and facilitators shaping implementation of EHRs in South Africa. The findings emphasize the need for balancing between top-down and bottom-up approaches through integrating strong policy leadership with meaningful stakeholder engagement to navigate contextual and systemic challenges. Together, a top-down approach provides centralized and strategic direction with resource allocation while bottom-up fosters user engagement which promotes adaptability and local ownership. To advance EHR implementation, it is essential to address leadership gaps, investing in infrastructure, creating a pathway for system interoperability and adopting user centered design principles are critical steps to achieving a robust national electronic health record system, a key pillar in realizing Suth Africa's vision for national health insurance.

Keywords: Electronic Health Records (EHRs), user engagement, implementation, barriers, facilitators, South Africa.

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CHAPTER 1: Introduction

1.1. Background

Digital health has revolutionized health care delivery in so many ways through integrating technology into medical practice, patient care and health information systems management (1). As such, it includes a wide variety of innovations and tools ranging from telemedicine, mobile health (nHealth), wearable devices, artificial intelligence all aimed at improving efficiency and patient outcomes (2). Through leveraging digital health solutions, healthcare systems can provide care that is more proactive, personalized, efficient and accurate, all of which are much needed especially in resource constrained settings (3).

One of the most significant advancements and innovation in digital health is the electronic health record, which have grown to replace traditional paper-based patient health records to provide a more seamless data sharing and coordinated patient care (3,4). As health care moves towards more integrated solutions, EHRs have become more significant in supporting clinicians through modernizing information management and streamlining workflows (4). In addition, EHRs have the potential to empower patients as well by providing them with access to their medical records and promoting self-management of chronic illnesses through the use of patient portals (5). Patient portals allow patients to also schedule appointments, request prescriptions and communicate with health care providers (5).

What is an electronic health record (EHR)?

Electronic health records (EHRs) are digital version of a patient's health record that are designed to collect, store and manage comprehensive and longitudinal patient health information (6). They include a wide range of information such as medical history, diagnoses, treatment plans, medications, radiology images and laboratory results (7), allowing the seamless retrieval and storage of health information for health care providers. By streamlining and automating the delivery of care processes, EHRs support clinicians, which can lead to improved patient outcomes and operational efficiency (8). Thus, EHRs play an important role in expanding the provision of

care (9), enabling healthcare professionals to access and share patient information across healthcare facilities for a coordinated delivery of care (10).

Typologies of EHRs

EHRs take different forms depending on their design and the context their used. As such, typologies can be described in different ways which include but are not limited to: by hosting, by licensing model, by system structure and by use case (11). The hosting typology refers to locally hosted on-site servers where the system is remotely hosted and data stored off-site or using cloud-based solutions. The licensing typology includes proprietary systems that are licensed by private software vendors, which are often compared with open-source platforms that are supported by governments or development partners. EHRs by system structure are integrated systems that consolidate multiple functions into one platform or a modular system that combines separate components linked through interfaces. Lastly, the EHRs by use case are comprehensive general purpose as it tracks all patient interactions or disease/programme specific records that capture only specific aspects of care such as HIV or Tuberculosis.

Evidence on EHRs and quality of care improvement

EHRs have been associated with enhanced quality of care, with several studies showing how they have contributed to reduced medical errors, improved and early detection of diseases, and improved patient safety through automated alerts (12,13). For instance, EHRs have also been shown to improve preventative care measures, with studies reporting how EHRs increased paediatric vaccination rates through reminder systems (14). Unlike traditional paper records, EHRs can offer real time access to patient histories, lab results and treatment plans, which enhances clinical decision-making by consolidating and aggregating patient information in a single access portal (15). EHRs can include enhanced functionalities such as the inclusion of decision support tools, computerized physician order entry and in some cases they are integrated with other health information systems (16,17). In cases where EHRs are integrated with other systems, this can facilitate continuity of care as information sharing between clinicians enhances coordination of care (18). Moreover, they can empower policy makers and decision-makers to identify trends and make data driven public health decisions (19). Some systems also include

portals where patients can access their records and manage their own care, further empowering patients (20). However, there have been concerns about usability as studies have reported user burnout due to excessive documentation requirements with EHRs (21).

Potential pitfalls of EHR use

Although EHRs are widely regarded as tools, EHRs have come with several challenges such as high costs, implementation failures, cybersecurity risks, workflow disruptions and poor user acceptance. Furthermore, while there has been considerable progress in adoption of EHRs among high income countries, but adoption in middle income countries (MICs) has been relatively slow (22). This has been due to several reasons which include technological, socioenvironmental and organizational factors (22,23). For instance, the high costs associated with acquiring and sustaining EHRs can pose significant financial challenge for MICs, especially in resource constrained settings (24,25). Additionally, infrastructure limitations such as poor internet connectivity, limited hardware, and inconsistent power supply, further impede EHR functionality and adoption in these settings (26,27). In addition, the environmental impact of EHRs is often overlooked, as the increased demand for infrastructure can lead to higher energy consumption and electronic waste (28).

Cost effectiveness and financing of EHRs

The cost effectiveness of EHRs is a contested issue, with studies showing that while the initial costs are prohibitive, EHRs can eventually lead to lowered health costs and long term cost savings if implemented and used correctly (29,30). Studies have reported positive financial return on investment and improvement in revenue through efficiency gains and reduction of errors (31), with one study reporting a reduction in adverse drug events significantly saving up to 22% of the costs spent on technology (32).

Despite these high costs and potential returns on EHRs, their procurement varies across countries and healthcare systems, as some nations such as the United Kingdom have pursued centralized national EHRs, while others such as the United States have relied on market driven, hospital based procurement (33,34). However, EHR financing can often include a mix of private investments, government subsidies and sometimes a mix of the two.

Best practices for EHR design and implementation

To fully harness the transformative power of EHRs, several foundational components need to be in place. These include appropriate governance structures and a good EHR design and effective implementation strategies. Governance structures need to ensure that clear policies are in place to regulate issues on digital health initiatives, data security and privacy laws and ensuring appropriate infrastructure for digital health adoption (35). A good EHR design is crucial for usability and user acceptance, especially if they are user centred. Poorly designed interfaces can lead to adverse effects such as cognitive overload, clinician stress and prone to significant medical errors (36). Along with design, workforce training and change management strategies are critical to overcome resistance and ensure a smooth user adoption (37). Neglecting this aspect can result in failed implementation even with well-designed system.

Moreover, best practices for EHR design need to be considered at three interrelated levels namely the client level, provider level and system level. At client level, systems should be designed with respect patient rights to informed consent, transparency on data use and in some cases where necessary, giving patients autonomy or access to their own records (38). For provider level, EHRs must support efficient workflows through functions such as improving data accuracy, minimizing duplication of paper and user-friendly interfaces (39). These issues are crucial for adoption as providers are the primary users and thus need to be considered when designing systems to minimize the risk of poor adoption. Lastly, at system level, EHRs need to be suitable for a health system approach to include functions such as interoperability, record linkages and procedural access controls (40). In most cases, unique patient identifiers are a foundational requirement for linking records across facilities, provinces and nation-wide, without which, systems risk remaining fragmented.

1.2. Problem statement

In low resource settings, including Sub-Saharan Africa, EHR implementation faces several hurdles, including low computer literacy among users, inadequate infrastructure and a high staff turnover rates (41). In some cases, EHR systems that are developed and tested in different contexts are introduced but fail due to their complexity and lack of alignment with the needs of local users

and workflows (30). This is because implementation often involves tensions as technological change can disrupt existing workflows, relationships and routines (42). Therefore, successful EHR implementation requires balancing the interplay between systems, people, processes and the product itself (41,42).

Despite the potential of EHRs to transform healthcare delivery (9,43), implementation in middle income countries (MICs) remains fraught with a combination of contextual barriers, implementation failures, and constrained capacity to sustain systems over time (23,44). Therefore, exploring the context specific challenges and identifying potential strategies to overcome them is an important step towards successful implementation of high quality EHRs (44). Like many other middle-income countries, South Africa plans to achieve universal health coverage through a national health insurance fund (45). This requires a robust national EHR system for a strategic purchasing and public fund utilization (46). However, EHR adoption in South Africa has been slow despite the presence of policies promoting the digitization in health care. This shows how barriers to EHR adoption in South Africa are not only technical or process-related but also embedded in broader health system and policy dynamics, as policy commitment has not been matched by effective strategies for EHR adoption. This PhD explores the factors affecting the implementation of EHRs in South Africa, identifying the challenges and potential strategies to ensure successful implementation.

1.3. Research aim

The overall aim of this study was to examine the implementation challenges and identify potential strategies to ensure high quality EHRs in South Africa.

1.4. Research objectives

The following were the three research objectives for this PhD:

Objective 1: To explore the current viability and associated challenges of implementing EHRs in South Africa as envisioned in the National Digital Health Strategy (2019-2024).

Objective 2: To explore an attempted implementation of a digital health system similar to an EHR (E-tick), examining how its implementation stalled despite following a consultative approach in its implementation.

Objective 3: To systematically synthesize international evidence on the user engagement strategies in the implementation of EHRs.

1.5. Key terminology list

Acronym	Full name	Description (Use in thesis)
CFIR	Consolidated Framework for Implementation Research	Implementation science framework used in Paper 2, which provides structured constructs to analyses barriers/facilitators of interventions.
DHIS	District Health Information System	South Africa's routine health information platform that aggregates facility-level service data, not patient-level records.
DHMIS	District Health Management Information System	Broader South African framework for district-level health information management.
DH	Digital Health	Broad term that describes the use of information and communication technologies (ICT) and other digital tools for health care delivery.
eHealth	Electronic Health	The broad use of information and communication technologies (ICT) to support health and health-related fields.
EHR	Electronic Health Record	A digital version of an individual patient's health record, containing longitudinal health information (demographics, diagnoses, treatments, medications, lab results).
EMR	Electronic Medical Record	A digital version of a patient record but typically facility-based digital record (limited to one institution or provider). Less comprehensive than EHRs, which are designed for sharing across settings.
E-tick	Electronic Tick Register	Case study intervention piloted in Ekurhuleni district; A digitized paper-based tick registers for patient consultations but was not a full EHR.
HIC	High Income Countries	A classification of countries with higher GDP per capita, often used in comparisons with LMICs.
HIE	Health Information Exchange	Networks or platforms that enable sharing of health information across systems and providers; support interoperability and data movement.

HIS	Health Information System	System-level infrastructure that collects, manages, and uses health data (population-level, program-specific, or facility-based). May include EHRs, DHIS, Tier.Net or HPRS.
HPRS	Health Patient Registration System	South Africa's patient master index system designed to register patients by assigning unique identifiers and support interoperability across health systems.
ICT	Information and Communication Technology	Refers to the diverse range of technologies and tools that enable the creation, storage, processing, and exchange of information and data. It underpins all digital health systems and infrastructures.
LMIC	Low- and Middle- Income Countries	Countries classified by World Bank based on income levels. South Africa falls into this category.
NDOH	National Department of Health (South Africa)	The main government body responsible for health policy, planning, and implementation.
NHI	National Health Insurance (South Africa)	Planned financing reform aimed at universal health coverage. EHRs are considered critical enablers for service delivery, monitoring, and strategic purchasing.
NPT	Normalization Process Theory	Framework used in Paper 3 to examine how new practices (like EHRs) become embedded and sustained in routine practice.
PHC	Primary Health Care	Includes entry-level health facilities such as clinics and community health centers to provide essential health services
Tier.Net	Three Interlinked Electronic Registers	South Africa's HIV and TB electronic register, widely used but disease-specific, thus often cited as a siloed digital system.
TMF	Theories, Models and Frameworks	Collective term used in implementation science to describe theories, models and frameworks used to guide design, analysis, and interpretation of health interventions.

1.6. Structure of integrating narrative

This thesis follows the course of 9 chapters through which different aspects of the study will be explored and reported on as follows:

Chapter 1: Introduction

This chapter introduces the PhD research and gives an overview of the South African health system and the challenges that are identified and addressed in this report. This includes the research problem; research aim and objectives and research questions that were answered.

Chapter 2: Literature review

This chapter provides a comprehensive review of the literature on the implementation of EHRs, examining the progress made to date and the reported challenges globally, in LMICs and in South Africa. It also explores the existing frameworks, models and theories of implementation, detailing the motivations for selecting and applying those utilized in this study.

Chapter 3: South African health system

This chapter describes the South African health system landscape. It situates the research within the context of South Africa, outlining the country's key characteristic, policy processes contemporary challenges in relation to EHR implementations.

Chapter 4: Methodology

This chapter details the research approach and methodology for the PhD study, covering the research design, study setting, participants, sampling and data collection procedures across the three research objectives. In addition, it covers the steps taken to prepare, manage and analyze the data for reporting and the researcher's positionality in this work.

Chapter 5 - 7: Results

This chapter presents the research findings through the three research articles developed and published during the study.

Chapter 8: Discussion

This chapter summarizes and discusses the findings from the three papers presented in the results chapter. This chapter also includes implications of the study, limitations of the study and areas for further research.

Chapter 9: Conclusion

This chapter concludes the study by providing a summary of key findings, contributions to knowledge, recommendations and concluding remarks.

CHAPTER 2: Literature review

2.1 Health policy and systems research as a conceptual framework

Although this thesis is rooted in implementation research, adopting a health policy and systems research approach situates EHR implementation within broader dynamics of the South African health system. In similar middle income contexts, the barriers to adoption are rarely confined to technology or facility level factors, rather, they often involve systemic issues such as governance, infrastructure and financing. This shows how the implementation of EHRs occurs within interconnected forces of a health system, highlighting the social and political nature of these processes (47). Health policy and systems research (HPSR) recognizes that health systems and policies are embedded in socially and politically contested contexts (47). As such, it provides a critical lens for understanding the complexities of health systems, the interactions between various actors and how policies shape health outcomes (47,48). It goes further by examining contextual issues such as governance, financing and human resource within health systems (49). HPSR is useful in exploring how policies are developed, implemented and how this process is influenced by stakeholders, as a holistic approach (50).

The World Health Organization's framework for health systems describes six interlinked building blocks which include 1. Service delivery, 2. Health workforce, 3. Health information, 4. Medical products and technology, 5. Financing and 6. Leadership and governance (51). These blocks form the foundation of a functioning health system, particularly through the relationships and interactions between them. Therefore, interventions such as EHRs are viewed as one part of a larger system, which can potentially create ripple effects in others by either improving them or bringing unintended challenges. Crucially, people are at the centre of this framework as service users, service providers, managers, policy makers and citizens whose actions and decisions drive the performance of the system (51). As such, a health system can be ultimately judged by whether and how it achieves its goals and responsiveness to people's needs.

Similarly, implementation science provides frameworks that are useful in examining EHR adoption processes, it is narrower in scope when compared to a health policy and systems approach, which recognizes the multiple intersecting forces shaping implementation (51). Moreover,

implementation science can be prone to disciplinary capture, through the imposition of a particular knowledge frame that privileges some questions and methodologies over others (52). This tends to assume that solutions to implementation problems may be already validated and primarily dependent on removing bottlenecks while overlooking contextual and system wide dynamics. In contrast, health policy and systems thinking places emphasis on whether interventions such as EHRs work but also how and why they do so, under what circumstances and with what consequences (47,52). However, the use of implementation science frameworks also speaks to the health policy and systems approach by ensuring that micro-level processes are analysed within wider system level dynamics.

This PhD applies the HPSR as a conceptual framework to critically explore the policies, implementation challenges and the role of key actors in South Africa's digital health landscape across micro, meso and macro levels (53). The adoption of this approach is a recognition of how health systems are shaped by broader social, political and economic contexts, positioning EHR implementation within these realities. Using the HPSR lens, this study contributes to a deeper understanding of how digital health initiatives, such as EHRs, can be successfully implemented and sustainably supported within South African health systems. Moreover, this research explores these processes in South Africa, a middle-income country with both unique and shared challenges.

2.2 Evidence on EHR implementation: An overview

A growing body of literature, including systematic reviews have explored various aspects of EHR implementation, including contextual barriers, facilitators and the impact of EHRs on health care quality (7,23). Some reviews have specifically provided insights into the progress, challenges and opportunities associated with EHR adoption, while highlighting the critical gaps for implementation.

For instance, two reviews of reviews have mapped out key factors influencing the implementation e-health systems (54,55). The first covered studies published between 1995 and 2009 and found 37 reviews, with 8 specifically related to EHRs (54). The second updated the search to include reviews from 1995 to 2014 and identified 7 more reviews to a total of 44, of which 9 examined

EHR implementation (55). In addition to highlighting the factors affecting implementation, both review of reviews also emphasized the need for further research on user engagement, particularly effective ways of engaging users to improve user acceptance, and sustaining engagement over time (54,55). Similar to these findings, recent studies also underscore user resistance as a key obstacle to EHR adoption (56,57) and report how poor user involvement in implementation (58) with clinicians adds to this challenge. In addition, other user related key barriers include workflow disruptions and poor training which hinder effective user adoption (59).

Despite these barriers, the reviews demonstrate that when implemented effectively, EHRs can enhance workflow efficiency and clinical processes (59,60). However, achieving this requires user centred designs and approaches, which remain overlooked (27,61). Moreover, there is a growing recognition that EHR implementation also depends on holistic approaches that consider comprehensive factors which include human, organizational and technological factors (61).

EHRs are complex sociotechnical systems whose success hinges on user satisfaction and successful adoption (13). Although recent reviews acknowledge the importance of user involvement, with primary studies frequently mentioning user engagement efforts, there has not been a systematic synthesis of best practice evidence for effective user engagement in EHR implementation (62). Among the reviews that emphasize user involvement, there is still a lack of empirical research on how user engagement affects implementation outcomes (58). This gap underscores the need for research into implementation strategies that include user engagement and user participatory design approaches to address implementation challenges and improve overall adoption rates.

The adoption and use of EHRs has significantly increased over the past 2 decades, with 27 high income countries reporting their widespread use by 2021 (63). However, the implementation rates vary across different countries with some establishing unified national EHR systems while others have fragmented systems. A 2015 World Health Organization (WHO) survey in the European region found that 59% of member states had a national EHR system, primarily in higher income countries as 18 out of 29 countries with national EHRs were HICs, 11 being middle income and none of them being low-income countries (64). Of the 11 MICs with national EHRs, 4 are from

the CIS region (Azerbaijan, Belarus, Georgia, Ukraine), 3 from CARINFONET (Kazakhstan, Kyrgyzstan, Tajikistan), and 4 from SEEHN (Moldova, Montenegro, North Macedonia, Serbia). Some of these countries, such as Montenegro and North Macedonia, are relatively small, with populations under 2 million. When compared to South Africa by population size, implementing an EHR in these countries would be equivalent to implementing one in a single province, such as Gauteng or the Western Cape. However, other factors need to be considered on the successes and challenges when drawing such comparisons. For instance, larger middle-income nations like China and India have populations of over a billion in size, which predisposes their EHR implementation efforts to become more complex and resource intensive. This variation in implementation trends may also be viewed as a reflection of different policies, investment and in some cases health priorities, all of which form the forces that shape health systems in their contexts.

From this report, several key observations were noted. First, from all the middle-income countries that responded to the survey, a majority of upper middle-income countries had implemented national EHRs, with less than half of lower middle-income countries reporting the same. Moreover, none of the lower middle-income countries had specific legislation governing the use of EHRs.

Best practices for EHR design

EHR design is an essential component and a key determinant factor of how well it is to be adopted by its intended users. As such, designs may vary depending on user needs or purpose of system such as the management of chronic diseases like TB management or HIV (65). However, at the core of it all, EHR design is considered good if prioritizes usability and ensures that systems align with clinician workflows, making them tools for improving clinical efficiency, which can be attained through user centred principles, which prioritize usability as a key feature to user acceptance (66). When users understand the purpose of the system and feel their needs are addressed, they are more likely to embrace the technology, which further enhances adoption and integration. Moreover, features such as intuitive interfaces, customizable templates, real-time decision support, and interoperability with other health systems contribute to their effectiveness

(67). This means EHRs should have architectural flexibility, allowing them to be scalable and to accommodate the evolving health work needs of users. Additionally, EHRs should incorporate strong security measures to protect patient confidentiality and comply with data protection regulations (68). Given the increased risk of data breaches and its risk on human lives, EHRs containing sensitive health information cannot be used efficiently at a national scale without having the necessary security measures in place (69).

Procurement and funding of EHRs

While good designs are an essential component to ensure successful implementation, there are several mitigating issues that are work exploring in the health ecosystem. One of these issues is how EHRs are procured and sustainably funded over time. For most countries, EHRs are procured through various models, depending on the country and healthcare setting. Governments often lead national implementations, as seen in publicly funded health systems (70), while private institutions may procure EHRs through direct purchase or subscription-based models (71). As EHRs are often found in both public and private health sectors, both stakeholders can be responsible for developing funding models that lead to successful adoption of EHRs. As a result, funding sources can include government grants, private investments, and hospital budgets in varying degrees of involvement depending on the context. In the public sector, governments can finance the adoption of EHRs through subsidies or directly investing into the development and use of systems (72). For private sectors, some EHR software vendors may offer EHRs under licensing agreements, while others use cloud-based, pay-per-use structures, reducing upfront costs but leading to long-term financial commitments (73).

2.3 EHRs in high income countries (HICs)

Global research on EHR implementation efforts has mostly been in higher income countries (HICs) with relatively limited but growing attention to lower to middle income countries (22,74). Lessons from HICs experiences can provide valuable insights into barriers, facilitators and what to expect when implementing EHRs in MICs (74). Moreover, to fully understand the realities of EHR implementation in both HICs and MICs, it is essential to also consider the political, economic and

social contexts and how they shape their outcomes (75), which are significant considerations when drawing insights.

High income countries (HICs) have generally led the implementation of EHRs, while middle income countries are gradually prioritizing EHRs among other digital health initiatives, despite their dissimilar contexts (76). In order to situate South Africa as a middle-income country and assess its efforts, it is important to also explore EHR adoption trends across different regions including case studies from both HICs and MICs. Globally, HICs have had more advanced EHR systems with robust policies and interoperability frameworks, extensive government funding and legal protections for patient data (61). Countries such as the United States, United Kingdom and Australia provide adequate examples of how HICs have achieved widespread adoption (77).

Understanding the HIC landscape: Case studies from USA, Australia and UK

Case study 1: United States of America

The adoption of EHRs in the US began as early as 2008, but widespread adoption became more prominent after the introduction of the Health Information Technology for Economic and Clinical Health (HITECH) Act, which spent over 30 billion dollars in funding in the first ten years to incentivise meaningful use of EHRs (78). Since then, adoption rates in non-federal hospitals have reportedly rose from 9.4% in 2008 to 96% in 2017. Thus, the US case was a market driven infusion, where adoption is influenced by factors such as financial incentives, competition and technological advancements rather than centralized mandates. As such, hospitals were incentivized to implement their own EHR systems, which allowed for tailored solutions. The US government has shifted its focus from merely increasing adoption rates to emphasizing meaningful use towards better economic and clinical returns (79).

While adoption rates in the US have been significantly fast, interoperability has presented ongoing challenges, which ultimately prevents the establishment of a national EHR. As a potential solution, the US explored health information exchange protocols to allow sharing of data across health facilities but many of the proprietary systems were not designed for exchange at the time (78). As a result, while high EHR adoption rates in the US are high, the integration of systems for a unified EHR have relatively not been successful.

Case study 2: Australia

The Australian government began investing in pilot projects to develop a national EHR system in the early 1990s. However, while various significant efforts of EHR adoption continued through the 2000s, a national electronic health transition authority was only established in 2005 to coordinate a national EHR, followed by an E-health strategy in 2008 to present a blueprint for an EHR project (81).

In 2010, the development of system began based on previous initiatives and adoption largely began with the introduction of the personally controlled EHRs (PCEHR) in 2012, to improve public health through federal funding (82). At this time, the cost of implementing EHRs in Australia came at an estimated AUD $ 2 billion (83). The PCEHR is a digital repository of patient health records where individuals can access and add information. A key success factor for EHRs in Australia has been the good foundation with high internet penetration among both patients and providers.

One of the main challenges impeding the Australian case was the poor stakeholder engagement and subsequently poor coordination presented problems to interoperability and secure data sharing (79). Interoperability was particularly necessary as Australia's private sector is quite large and may have viewed their systems as a competitive advantage. As a result, while early implementation efforts were erratic, involving different stakeholders, the country managed to harmonize the rifts between them and connectivity and integration of EHR systems (79).

Case study 3: United Kingdom

In 2002, the UK introduced the National Health Service (NHS) Care Records Service, an EHR system developed at a cost of over £12.7 billion (85). The government had planned to implement a nationally procured EHR system, becoming the first country to do this globally (86). Unlike the decentralized models seen in the US and Australia, the UK adopted a centralized, top-down strategy through the National Programme for Information Technology (NPfIT), which aimed to modernize healthcare service delivery (87). Through this approach, the government had a few contracts with specific chosen vendors for a nationwide implementation of EHRs, aiming to standardize EHRs across the NHS (88).

In the UK the national approach was too complex and led to implementation challenges such as user resistance as these systems had limited customizability and needed local adaptation (80). Unlike the US's approach, the UK had little room for tailored solutions and lacked health care provider engagement for customization of existing systems. Thus, while the UK's approach was likely to avoid interoperability challenges using standardized systems, this ultimately led to poor adoption of EHRs resulting from bureaucratic complications and resistance. In such a case, decision makers will be forced to decide between interoperable systems and risk user resistance or prioritize user acceptance then work on integrating systems over time.

Success factors from HICs

Evidence from HICs highlights several critical factors for successful EHR implementation including leadership and stakeholder engagement, a favourable policy landscape, financial investment, user training and support, user-centred design, and system interoperability. I discuss these themes below.

Effective leadership is a critical driver of successful EHR implementation (81). When leaders engage stakeholders early and consistently, they create a sense of ownership and alignment with the system's goals (82). Leaders who set a clear vision and actively oversee the process are better

positioned to foster buy-in from diverse stakeholders, including clinicians, NGOs, private sector organizations, civil society, and parastatals. The U.S. experience for instance, showed that collaboration with stakeholders enables the sharing of skills, resources, and experiences, which significantly enhances the likelihood of success (83). The U.S. government encouraged multiple stakeholders, including clinicians to become active participants at local, state and federal levels (77). One of the main distinctions between HICs and MICs is their capacity to fund for health initiatives such as EHRs, and leaders are especially key in developing sustainable funding models.

Having a strategy for implementation is a key factor to successful EHR implementation in HICs (84). The strategies can be supported by policies which favour the adoption and use of EHRs such as the HITECH Act in the US, which incentivised health care providers to use EHRs and became an effective approach to encourage meaningful use. Countries may adopt different approaches, as the UK opted for a top down approach where the government decided to procure standard systems for a mandated nationwide use (77). On the other hand, the U.S. focused on a bottom up approach by making local systems compliant with interoperability standards, while Australia adopted both approaches, harmonizing private and public sector efforts (77). These strategies illustrate how national governance structures can shape digital health policies and implementation approaches.

Despite some hurdles with inadequate training, HICs also prioritize training and support as key issues for successful adoption, especially with end users (85). This is essential because well trained users are empowered to use the systems well and their proficiency minimizes the risk of collecting poor data (86). Some HICs such as Germany went further to introduce extensive training in medical education to prepare and ensure that future health care providers are equipped for the digitalization of health care (87). While EHR systems in HICs are sometimes designed with a focus on user needs and workflow integration (88), involving end users in the design process helps to align with their workflows, which makes implementation less disruptive.

A key marker of successful EHR implementation is the seamless data exchange across facilities, regions, and even nationally (89). For EHRs to truly transform health care, they need to be able to facilitate health information exchange between providers. However, many countries may have

successfully adopted EHRs, but most systems are designed as standalone silos without capacity for interoperability. The US and Australia have established standards for data sharing and interoperability, which not only facilitate communication between systems across different facilities but also allow for the integration of previously separate systems (77). This capability is essential for realizing the broader benefits of EHRs, such as improved care coordination and data-driven decision-making (90).

Implementation challenges from HICs

Despite the financial positioning of HICs in procuring EHRs, several obstacles have been noted such as high initial costs, system complexity and fragmentation, poor change management and physician burnout as in the cases of the US and the UK. This highlights that financial resources alone do not guarantee success but rather needs to be coupled with strategic planning. Therefore, while HICs are financially better positioned to invest in EHRs, the costs associated with procuring, implementing and maintaining EHR systems remains a major deterrent. However, the long term benefits such as improved efficiency may justify the investment in EHRs but still requires healthcare organizations to navigate budget constraints and financial scrutiny (91).

Technical challenges often arise in the adoption of nation-wide, standardized EHR systems, which require substantial skilled personnel to provide support for users. Avoiding these obstacles, the U.S. and Australia have adopted a more decentralized approach by involving private sector participation and outsourcing for much of their problem solving (63). Change management remains a challenge in EHR adoption as new systems often disrupt clinician workflows. Poorly managed transitions can lead to user resistance, and clinician burnout, resulting in errors in data collection (92).

2.4 EHRs in Middle Income Countries (MICs)

Although HICs have relatively more capacity to implement EHRs, MICs have had several benefits and opportunities to leverage to their own advantage, as the use of digital tools has been growing in middle and low income countries, especially in the sub-Saharan region (93). For instance, the widespread use of mobile phones for instance provides opportunities for leveraging mobile health (mHealth) to collect health data and extend the reach of care (94–96). South Africa

specifically, has successfully leveraged mobile phone technology to deliver maternal care (97). In some countries, the use of donor funded open source EHR systems often has emerged as a cost effective and customizable solution, which is an alternative to the procurement of expensive proprietary systems (25,30). Thus, MICs in their relatively slower progress in implementing EHRs, have shown a more varied landscape, with some nations such as Estonia, China, Brazil, Serbia and Slovenia making substantial progress while others face persistent challenges to implementation (64). Despite these challenges, opportunities exist to advance EHR adoption in MICs due to various factors.

Understanding the MIC landscape: Case studies from China and Brazil

It is essential to explore the experiences of MICs, considering the shared contextual barriers and facilitators, and in comparison, to HIC experiences to better understand the factors the unique barriers and facilitators presented by their health systems. This section explores 2 case studies from middle income countries, China and Brazil.

Case study 4: China (Upper middle income)

China experienced rapid EHR adoption starting in 2007, driven by a government investment of $3.5 billion dollars alongside national policies and technical standards (107). This led to an increase in hospital adoption rates, rising from 18.6% in 2007 to 85.3% by 2018 (107). During this period, over 16,000 hospitals in China implemented EHRs, which was at a much higher by proportion compared to the US's 4800 non-federal hospitals.

To standardize implementation, China's government through the National Health Commission introduced a grading system with levels 0-8 to guide integration and ensure interoperability (107). By 2011, about 120 EHR systems had been completed, with 40 undergoing development and a 100 more in the planning phase. In 2014, about half of all tertiary hospitals, 30% of urban community health care centres and 20% of rural hospitals had their own EHRs (108). The Chinese market has also attracted EHR service providers locally and internationally such as IBM, Dell, Cisco and Siemens (108).

At present, the government of China is planning to introduce an integration strategy through the Regional Healthcare Information Networks to utilize data centres and telecommunication as platforms to facilitate health information exchange. This was followed by an electronic health card which allows facilities across the country to recognize each other and share information (109).

In China, the rapid growth in EHR adoption was primarily due to government led policies, via a top-down approach, where EHRs were positioned as key performance indicators for public hospitals (98). Compared to the market driven, non-linear (S-shaped) diffusion pattern by the US, China's approach was linear and centralized, relying heavily on government mandates and directives.

However, China initially faced challenges with financial constraints given the scale of the project and size of the country as well as shortage of IT staff to support this transition, particularly in the early adoption stages (99). This was worsened by regional disparities in medical resources

distribution which made implementation efforts uneven. Moreover, the centralized approach brought systems that were inflexible with limited customization for hospital IT departments, making it difficult to meet the diverse needs stakeholders (100). Thus, despite the rapid adoption, interoperability challenges emerged as the data was largely unstructured data and the systems had limited retrieval capabilities (101,102).

Case study 5: Brazil

In 2011, Brazil's Ministry of Health launched an initiative to digitize the health system, focusing on primary health care. However, efforts to develop an EHR had begun earlier with a task force dedicated to designing a strategy for the implementation of a system to record and manage primary health data (114). The task group, comprising of stakeholders from the Ministry of Health, municipal and state health department, academics and the private sector, collaborated to highlight the need for EHRs in primary care. Their effort led to a partnership between the Ministry of Health and the Federal University of Santa Catarina, culminating in the establishment of the Bridge Laboratory, followed by the development of the PEC e-SUS APS, a national citizens electronic health record available free of charge to all municipalities as it was government funded (115). The system underwent significant evolution and grew exponentially with adoption in municipalities growing from 8,930 to 26,091 units between the years 2017 and 2022, at which point it represented 59.93% of the EHRs used in primary health facilities (114).

Brazil faced several implementation challenges including inadequate training for health care providers, the intended end users of the system. Additionally, infrastructural barriers such as poor internet connectivity particularly in remote areas, hindered progress (19). Therefore, factors such as location, urbanization, population density and computer literacy were determinant factors for successful adoption. Finally, while the government led system improved through continuous development and updates, interoperability was a challenge especially with third party systems at

different levels of care. Efforts to establish interoperability have been made through a national standard to support information exchange particularly between providers and health insurance companies (11).

Lessons from the MIC experience

The case studies show that MICs also face barriers and facilitators to EHR implementation. As such, some barriers and facilitators are more uniquely experienced in MICs while others are also experienced in HICs. For instance, limited funding and resources has been consistently reported as a major barrier to implementation in MICs (23,64). As a result, many MICs such as Brazil, India and Myanmar face various challenges with inadequate infrastructure such as reliable electricity, internet connectivity and hardware to support EHR implementation (103–105). MICs also face challenges with ensuring the security and privacy of data as legal frameworks to ensure this may be less developed (23). Moreover, health systems in some MICs also need leadership that ensures stakeholder buy in as preparation for a coordinated effort of EHR implementation (27). This has primarily given HICs such as Australia and the US an edge as their vision to implement EHRS stems from over 20 years ago.

Potential downsides of EHR implementation

While EHRs are often seen as transformative, they come with drawbacks, including the high costs associated with initial implementation, which can impede EHR adoption in smaller facilities (106). Furthermore, implementing EHRs can be resource intensive beyond adoption, which affects several other issues such as staff training, system maintenance and interoperability issues which are long term needs (107). EHRs also have an environmental impact due to energy-intensive data centers and electronic waste from outdated hardware (108). Thus, while EHRs may lead to more emissions than paper-based systems, their benefits still outweigh the challenges. However, they are still a more viable option given their impact on transforming the delivery of health care. Additionally, some studies show that poor system design or inadequate user training can lead to inefficiencies, clinician burnout, and potential medical errors (109). This is due to the cognitive burden of having to deal and work with a system that is not user friendly and difficult to understand.

The role of context in EHR implementation

As illustrated earlier, the success or failure of implementation efforts is significantly shaped by contextual factors, including governance, economic conditions, health systems capacity and other broader sociopolitical dynamics. While HICs like the USA, UK and Australia generally have the financial and infrastructural capacity to support widespread EHR adoption, middle income countries such as Brazil and China may face challenges and opportunities that must be carefully considered (110). For instance, Brazil used a decentralized approach to EHR adoption and was able to find solutions for several challenges through partnerships with local academic institutions. This shows that implementation models can leverage a hybrid approach which supports an open source, offline EHR to overcome the challenge of unstable internet access (111). Some similarities may exist, but contextual factors can lead to dissimilar outcomes.

For instance, some MICs may have well-articulated policies, similar to most HICs, but a weak enforcement and lack of political will has often hampered efforts to implement EHRs (112). MICs have been able to find solutions to their specific challenges in many ways, such as leveraging mobile health technologies to deliver health, a tool that can be used to complement EHR systems.

Therefore, although HICs experiences can provide insights, the implementation of EHRs in MICs still requires strategies that are responsive and adaptive to their unique contexts (113). By developing localized solutions, decision makers can identify barriers such as governance and infrastructure and effectively find solutions to them for a sustainable EHR adoption.

The comparative analysis of EHR implementation across HICs and MICs demonstrates some challenges such as fragmented systems, poor governance and lack of interoperability are common globally and not unique to South Africa. These recurring issues highlight the need for structured approaches that can unpack the interaction between context, processes and actors involved in shaping implementation outcomes. This recognition warrants the use of theories, models and frameworks that offer systematic tools for analysing implementation efforts and the reasons behind their success or failure. The following section introduces relevant theories, models and frameworks, and show how they can be useful in identifying, understanding and addressing barriers in South African context.

2.5 Theories, models and frameworks for implementation

Theories, models and frameworks (TMF) are foundational parts of research and implementation science (114). Theories are often used to explain the causal mechanisms underlying implementation processes, while models are used as practical guides for translating research into practice (115,116). Frameworks on the other hand, are used as structured checklists of factors that affect implementation (116). Thus, while a theory explains why things happen, models provide a structured process to explain how they happen. This study draws on multiple TMFs to understand implementation processes in complex adaptive systems such as health care settings (117), which is useful in exploring the barriers and enablers to user adoption of EHRs. Health care settings are complex adaptive systems, consisting of multiple, interconnected components that interact dynamically towards a common goal (118,119). TMFs are thus especially valuable in these environments as they offer evidence-based tools to assess implementation of health interventions.

In middle income countries (MICs), TMFs are useful as evidence-based tools that have been tested and refined across diverse contexts, despite being dissimilar in many ways (120). They also provide a structured approach to evaluating implementation processes, rather than relying on costly and less efficient trial and error methods (121). Moreover, TMFs enable MICs to benchmark their progress against global standards, and to draw insights to anticipate potential risks and develop strategies to mitigate them. By leveraging TMFs, MICs can enhance their implementation efforts and improve their chances of achieving sustainable and scalable outcomes (122).

This study draws on several TMFs, each addressing crucial elements of implementation science such as implementation strategies, evaluation considerations and influencing factors (123). Some of the influencing factors include motivation, behaviour and organizational dynamics, as well as contextual factors such as policies and sustainability. While there may be overlap between TMFs, the selection focus was on identifying the most relevant by examining their differences (124). As a result, the selection process was guided by criteria such as empirical support, applicability to the chosen setting or population, testability, description of a change process and the analytic level (125). Thus, given the extensive range of existing TMFs, eight were identified as potentially useful

for this PhD, a total of four theories, two models and four frameworks, but only two were finally used in this study.

Theories

1. **Normalization Process Theory (NPT)**, which focuses on how new practices are implemented, embedded, and integrated into routine work (126).
2. **Diffusion of Innovation Theory (DOI)**, which describes how innovations spread through populations over time (127).
3. **Actor-Network Theory (ANT)**, which examines the relationships between humans and non-human actors (e.g., technology) in networks (128).
4. **Unified Theory of Acceptance and Use of Technology (UTAUT)**, which explains user acceptance and usage behaviour of technology (129).

Models

1. **Technology Acceptance model (TAM)**, which predicts user acceptance of technology based on perceived usefulness and ease of use (130)
2. **Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM)**, used to evaluate the impact of interventions across multiple dimensions.

Frameworks

1. **Consolidated Framework for Implementation Research (CFIR)**, a framework that provides a structure for assessing implementation contexts and processes (131).
2. **Non-adoption, Abandonment, and Challenges to the Scale-up, Spread and Sustainability (NASS)**, which identifies barriers to the adoption and sustainability of health technologies (132).

Rationale for TMF selection

In selecting the theories and frameworks for this study, the goal was to capture the full complexity of implementing EHRs in South Africa. While all TMFs considered had their unique strengths in capturing this issue, theories such as the Diffusion of Innovation Theory (DOI), the Actor Network

Theory (ANT) and the Unified Theory of Acceptance and Use of Technology (UTAUT) were ultimately excluded. This was primarily because their focus was either too narrowly on specifics such as individual technology acceptance or it lacked the depth needed to address the complexity of health systems, which is a core aspect of this research (133). For instance, the DOI is useful for understanding how innovations spread through people but lacks depth in detailing insights into organizational or relational dynamics the way the NPT and CFIR do. Similarly, ANT's focus on the human and non-human relationships could have been useful but it is less applicable to the specific issue of health care providers adopting EHRs. UTAUT is also insightful in technology acceptance, a key component of EHR adoption, but does not capture broader contextual factors from a health systems perspective.

NASS as an alternative framework

Although the NPT and CFIR were chosen for this study, it is important to consider the Non-adoption, Abandonment, and Challenges to the Scale-up, Spread and Sustainability (NASS) framework as a potential option. The NASS more specifically focuses on the barriers to adoption and sustainability of health technologies, and explores factors such as resistance to change, organizational challenges and technological factors that impede widespread adoption and sustainability of interventions (132). However, NASS focuses on patient centred issues, which were not the focus of this study as the NPT was chosen to focus on end user experiences. Moreover, NASS does not adequately address the complexity of interactions between different stakeholders in the way the CFIR does, making it a narrow miss for selection. While other TMFs were considered, they appeared limited in scope, often by focusing solely on either outcomes or individual factors, falling short in capturing the complexity of implementing EHRs in MIC settings (123).

CFIR and NPT as core theories for this study

In this study, one framework (CFIR) and one theory (NPT) were chosen as well suited for the aim of this study. The selection of these theories is further informed by a health policy and systems research perspective, which emphasizes the interplay of multiple factors and acknowledges that

health systems operate within complex social and political contexts (49). These environments significantly shape health decisions and policies.

The CFIR provides a comprehensive and multilevel approach to examining factors influencing implementation at the individual, organizational and external levels (131). The framework has been tested in various contexts and adapted across different contexts, ensuring its validity and reliability (134). This is useful in a context like South Africa, a resource limited country where multiple factors are intersecting in shaping the health landscape. The NPT on the other hand, focuses more narrowly on how new interventions, such as EHRs, become embedded and integrated into user workflows (126). This is useful in exploring how people make sense of new interventions, engaging with it and collaborate to make it part of their workflow. Using both theories was essential in overcoming the shortfalls of the other, allowing a more holistic approach where the CFIR identifies the key factors influencing implementation at a broader level while the NPT sharpens the focus on user adoption and how to embed EHRs. Thus, by using both the CFIR and the NPT, we address both the "what" and "how" of EHR implementation in South Africa.

Complexity in implementation: The role of NPT and CFIR

When considering the complex nature of health care settings and the implementation of EHRs in such settings, both the NPT and CFIR offer valuable insights into how health systems can affect implementation outcomes. For instance, the NPT is inherently tied to complexity because it focuses on how new interventions or practices such as EHRs are integrated into routine workflows and ultimately normalized in health care settings (135). This implies that the NPT allows the exploration of how different factors interact to either promote or hinder he adoption of EHRs, aligning with this study's recognition of health care settings as complex systems.

Similarly, the CFIR addresses complexity by offering a comprehensive and multi-level approach to understanding the factors that influence the success of implementation efforts, ranging from individual to organizational and external factors, including how they may evolve over time (136). By recognizing that implementation does not occur in isolation, this framework is particularly useful in exploring how implementing EHRs would require navigating through health systems such as South Africa.

CHAPTER 3: The South African Health System

3.1 EHRs as a cornerstone for transforming the South African health system

South Africa's health care system operates as a two-tiered structure, divided across socioeconomic lines, resulting disparities in access to health care (137). Although public health care is nominally free for all South Africans, the unequal distribution implies that the quality and access remain inconsistent across people of different income groups (138). Although South Africa allocates a higher proportion of its GDP towards healthcare than the average upper middle-income country with , systemic inefficiencies in how the funds are utilized continue to hinder service delivery (139). As a result, the public sector serves the majority (84%) but remains under-resources relative to the demand while the private sector consumes a relatively larger spending proportion despite serving the minority (16%) (140,141). The financing arrangement are mixed, with public funding generated primarily through taxation and private sector's revenue coming from insurance and out of pocket payments (141). These financing patterns produce stark disparities in capacity, workforce distribution and technological readiness between regions.

At present, South Africa is in the process of implementing the National Health Insurance, a reform aimed to consolidate health care funding and to enable better purchasing decisions through formal contracting relationships (45). EHRs are a critical and central component to this vision as they offer tools for monitoring of patient outcomes, facilitate resource allocation and overseeing purchasing decisions (139). Policy documents often link EHRs with strategic purchasing under South Africa's National Health Insurance (142), as digital longitudinal and interoperable patient data is essential for facilitating provider payment among other functions. However, the role of EHRs goes beyond their contribution to purchasing only as they also enable continuity of care, supporting clinical decision making (143). These functions can underpin quality assurance by enabling routine monitoring of health outcomes and indicators as well as support care coordination. At a system level, linked patient records can improve surveillance, planning and resource allocation, a useful function in South Africa where the burden of disease is high (144).

At present, governance in South Africa follows the federal system, which ensures that the national department sets the policy mandates, while the provinces retain autonomy in implementation

and budget allocation (140). As a result, this decentralized system allows provinces to independently tailor health care service delivery when making decisions on health care spending including digital health initiatives. This institutional landscape is an important consideration for digital health as it helps to explain issues such as fragmented financing and uneven infrastructure can shape disparate levels of digital readiness. The consequence is that national policy aspirations such as implementing a national EHR, are frequently hampered by the practical limits of provincial capacity, competing priorities and varying levels of political will or commitment.

3.2 South African digital health policy landscape

South Africa has introduced several policy initiatives over the past 25 years to promote digital health and improve health information systems across public health facilities. These include the National Health Act of 2003, which defines the roles played by national, provincial and local government to implement health information systems for health systems strengthening (145). This act mandates health departments to facilitate and coordinate the establishment, implementation and maintenance of the information systems. This is aimed at setting the foundation for the development of standardized data collection and reporting procedures. In 2011, the district health management information system (DHMIS) policy was introduced to formally standardise data collection and reporting across the country (146). This was aimed at ensuring a uniform approach to health information management. Building on this, South Africa had the eHealth Strategy (2012), aimed at creating a digital health environment by promoting interoperability of systems and fostering a seamless data exchange across all levels of care (147).

The most recent policy is the National Digital Health Strategy (2019 -2024), which outlines nine strategic interventions designed to accelerate digital health transformation in South African health care by 2024 (142). Some of the key priorities include the digitization of record keeping and the establishment of a national electronic health record, which is crucial for the enhancing the provision and continuity of care. South Africa's policy trajectory illustrates a clear ambition to strengthen digital health efforts, with early eHealth strategies setting out high level goals for digitization while the National Digital Health Strategy articulates a more concrete set of priorities that are necessary for the advancement of digital health landscape. While several efforts in policy

have been successful in South Africa such as the eHealth strategy, normative health standards framework and national digital health strategy (2019-2024), progress in translating these policies into effective real-world outcomes has been limited. This has been primarily due to a number of reasons including implementation challenges, lack of operational clarity, poor capacity and barriers to scale up (148).

Despite the policy efforts to modernize health information systems, most primary health care facilities in South Africa continue to rely on manual and paper-based record keeping (149). The absence of a national electronic health record could be attributed to the provincial disparities where some provinces are advancing towards digital integration while others lag behind. For instance, not all provinces have a fully functional system in public hospitals (150), and some provinces such as Limpopo remain faced with persistent challenges such as poor managing of medical records and inadequate infrastructure (151).

3.3 EHRs in South Africa: Systems, functions and fragmentation

South Africa's digital health environment is populated by a diversity of systems that perform different functions, from routine reporting to disease-specific registers and patient-level databases. For instance, the district health information software (DHIS) and the health patient registration system (HPRS) are among the key systems that have been introduced to standardize and modernize data collection in public health facilities (144). The HPRS, used in public health facilities, captures basic patient information such as contact details, age and gender, and it remains largely manually recorded. However, this system provides a basis for a national patient registry. The DHIS, introduced in 1996 and expanded nationwide by 2001, facilitates the aggregation of health service data from public health facilities in a country (153). Using this system, health care workers record patient interactions on paper registers, and data is submitted monthly to the district offices, where it is captured using DHIS software before it is reported to provincial and national levels. However, this manual transfer process can be time consuming and prone to human errors.

In addition to the broad health information systems, specialized standalone systems have been introduced for chronic disease management. One example is the Tier.net, a system used to

capture patient-level HIV data at facility level, which also integrates with the DHIS, allowing aggregated data to be automatically transmitted to the district health department (154). Despite these systems being in use, they often operate parallel to paper-based records, which can lead to redundancies and inefficiencies in data management. The proliferation of disease specific systems in South Africa also reflects the historical evolution of financing and health priorities as donor and NGO funded programs have primarily prioritized vertical digital solutions for HIV, TB or maternal and child health. While these systems deliver important gains for specific programmes, this has resulted in a fragmented ecosystem with many dissimilar platforms capturing only parts of the patient's experiences or conditions. However, systems such as DHIS and Tier.Net are health information systems (HIS) or disease registries, designed primarily for programme monitoring and reporting. In contrast, EHRs capture longitudinal patient information across multiple encounters and, ideally, across levels of care.

At facility level, different public health facilities have adopted several standalone digital health information systems. However, a major challenge has been that these systems operate in isolation from one another, thus not integrated or connected across different levels of care such as primary, secondary and tertiary care (155). Without a cohesive interoperable national EHR, health data remained siloed, making it challenging to coordinate care and ensure continuity of care. Scaling up and integrating these systems is essential for strengthening health care delivery including advancing South Africa's NHI agenda (156,157).

3.4 Conclusion

The South African context is an important consideration as it highlights the structural and policy factors that shape EHR implementation. In this case, three main issues are worth noting about the South African context. First, South African policy ambition exists as several strides have been made to keep policies relevant. Second, several health information systems have been introduced for public health facilities especially as registers for recording patient visits and services provided. Third, EHRs are key in facilitating the NHI, as the provision of universal health care demands attention to ways of managing strategic purchasing, a function carried by EHRs.

CHAPTER 4: Methods

4.1 Research design

This research is grounded in an interpretivist paradigm, which emphasizes the understanding of experiences of individuals, subjective meanings and their social contexts, including people's beliefs and motivations behind their actions (158). This paradigm is particularly suited for exploring the multifaceted nature of EHR implementation, which includes social, organizational and technical dynamics affecting adoption and use from various stakeholders.

A qualitative approach was adopted to explore the barriers and facilitators to implementing electronic health records in South Africa. This approach was used primarily because qualitative research designs offer more flexible and adaptability compared to quantitative studies, which often require predefined procedures (159). Thus, the qualitative approach was applied in the design of 3 objectives which include two primary studies with in-depth qualitative interviews and a rapid review. These objectives were developed iteratively and are interrelated, with each contributing and building on the overall aim of the study. The iterative process was shaped by three main factors. First, consultation and feedback from supervisors during early proposal stages helped to identify the initial areas of research focus and guided the framing of the research questions. Second, engagement with newly published literature on implementation science and digital health policy informed the formulation and alignment of objectives with contemporary debates. Third, reflections on emerging empirical insights during field work led to further refinement to ensure that objectives remained responsive to realities encountered in practice.

4.2 Study setting

A study setting can be described as the physical location or context in which research is conducted, ranging from broader geographical regions to specific areas such as organizations or health care facilities (159). As such, study settings in qualitative research can be based on the researcher's interests and may be selected to examine social environments and the interactions taking place within them (158). Moreover, while some settings may share common characteristics or be in the same geographical space, each retains distinct features that uniquely shape the

research context. This study was conducted in South Africa, with each objective focusing on different settings and contexts of EHR implementation as described below.

Objective 1 took a nationwide perspective, examining the factors influencing EHR implementation in South Africa, including the contextual barriers and facilitators. Participants were stakeholders drawn from private sector, non-governmental organizations, academics, parastatals and various levels of the department of health at district provincial and national levels across South Africa. This was done to provide a comprehensive assessment of the viability of implementing EHRs in South Africa.

Objective 2 was specifically based in Ekurhuleni, a district in the Gauteng province of South Africa, where an intervention of the electronic tick register (e-tick) was piloted in three community health clinics. This setting was found suitable case study to explore context specific issues and challenges of implementing EHRs. Ekurhuleni was chosen because it was the only district where the e-tick system was piloted, making it a uniquely appropriate case study for examining the implementation. Moreover, the district was valuable because the pilot was conducted across three healthcare facilities with different attributes and variations in size, patient volume and organizational dynamics, making it suitable for comparative analysis.

Objective 3 did not have a defined geographical setting, as it was a rapid review synthesizing global evidence from published literature. While the findings were derived from international contexts, they were not confined to a specific location or setting. The decision to conduct this review was driven by the need to gather global insights on best practices, policy and recommendations on EHR implementation.

Together, the three different approaches provide a well-rounded analysis of EHR implementation that integrates local (micro), national (meso) and global perspectives (macro) to provide a multi-dimensional understanding.

4.3 Participants, sampling and recruitment

Participant sampling refers to the steps taken to identify, select and recruit groups or individuals suitable to provide data for a study (160,161). In this study, purposive sampling was primarily used to capture diverse perspectives from people with relevant expertise and experiences of EHR implementation. This was only applied to objectives 1 and 2 whereas objective 3, being a rapid review, did not require participant recruitment.

In objective 1, purposive sampling was used to select 18 participants with professional experience across various sectors of the South African health care system, with some having direct involvement in the design, implementation, or evaluation of digital health systems currently in use in South Africa or held roles that gave them relevant technical or policy oversight. This approach ensured that individuals with first-hand knowledge of digital health efforts in South Africa were included. Participants were initially identified from a predetermined list of potential key informants based on their roles in public health. This list was further expanded through snowball sampling which allowed already recruited participants to refer others with relevant expertise (160). In total, the 18 participants included national, provincial and district health officials (8), parastatal staff (2), NGOs and NPOs (4), academics (2) and digital health private sector managers (2). This method was also useful in reaching individuals in senior positions who may have not responded to initial recruitment efforts.

Objective 2 involved 38 participants, comprising 18 participants recruited from objective 1 and an additional 20 participants recruited using a combination of purposive and convenience sampling. This approach ensured the structured recruitment of key stakeholders involved in implementing the E-tick system and to manage the practical challenges of participant availability particularly among clinicians who had used the system over the past 2 years. The originators were instrumental in identifying of key personnel who were directly involved in the development, implementation and use of the E-tick system. However, due to varying availability of participants, convenience sampling was incorporated particularly for clinicians who were engaged based on their accessibility during data collection. As a result, participants were grouped into 3 categories including the implementation team, the end users, and the senior management and stakeholders.

The implementation team included individuals who led the efforts to develop, deploy and pilot the system in the facilities. The group mainly consisted of the originators (2), the technician (1) and data capturers (3) who helped users in training, verification and providing reports to originators. The end users consisted of clinicians and facility managers from the three facilities who included facility managers (3), administration officer and clerks (3) and nurses and midwives (9). The senior managers and stakeholders were largely officials who were not directly involved in the implementation of the system but whose decisions and authority affected implementation.

The final sample size was considered sufficient to capture variation across stakeholder groups and ensure adequate depth for thematic analysis. In line with established qualitative methodology literature, the rationale for sample adequacy was based on diversity of perspectives rather than statistical representativeness (158,159,162). This approach ensured that multiple cadres involved in EHR implementation were included and that both system-level and facility-level experiences were represented.

4.4 Data collection

Data collection for objectives 1 and 2 were similar, and utilised in-depth interviews with semi structured interview guides as data collection tools, a method that is useful when the researcher has pre-existing knowledge about a topic (160). The interview guides were designed to align with specific objectives and targeted groups of participants, ensuring that key issues were explored. Therefore, the first 2 objectives utilized semi-structured interview guides as the primary data collection tools.

For objective 1, the interview guide covered topics on the digital health policy landscape in South Africa and the viability of the National Digital Health Strategy (2019-2024), existing digital health information systems in South Africa and the necessary next steps for EHR implementation (see appendix 9). From a total of 18 interviews, 16 were conducted virtually using video conferencing software (Microsoft Teams or Zoom) due to Covid-19 restrictions and safety precautions that were required during the time.

The interview guide for objective 2 was tailored to cater for different categories of participants, including stakeholders, facility managers, implementation team and end users. The interview

guides for the implementation team and end users focused on the origins and purpose of the e-tick system, implementation process, perceived benefits and challenges, and recommendations for further development (see appendix 11 and 12). The stakeholders in this objective were the same as those in Objective 1. For stakeholders familiar with the e-tick, their insights focused on the successes and challenges faced during its implementation. In contrast, those who were unaware of the e-tick system gave broader insights into the factors affecting similar efforts in the country. Interviews with the implementation team were conducted virtually, while facility managers and end users were interviewed in person at healthcare facilities during work hours, following the easing of COVID-19 restrictions.

Interviews were continued until no new themes emerged across major stakeholder groups, indicating that thematic saturation had been reached (158,159). For smaller groups of key informants, such as provincial managers, the emphasis was on capturing depth of experience rather than redundancy, and therefore data adequacy was judged by the richness of insights rather than saturation per se.

The third objective, being a review, did not involve primary data collection. Instead, it employed a systematic search of data from two academic databases, PubMed and CINAHL, using predefined search criteria. This process identified 41 published studies of qualitative and mixed methods design, describing user engagement strategies used during EHR implementation.

4.5 Data management

All interviews were conducted using the English language, audio-taped using an audio recording device and the audio files were stored in a password protected computer. Audio files were mostly transcribed using a transcription software, with only a few transcribed manually. All transcripts were checked for accuracy. During transcription, all participant identifying information was removed and pseudonyms were used to ensure participant anonymity and privacy.

For the third objective, studies identified in the search was screened using Covidence software and extracted into an excel spreadsheet and sorted authors, year of study, stud design, setting, participants and descriptions of engagement strategies used in each case. This is described in more detail in chapter 7 of this thesis.

4.6 Data analysis

Although this study was entirely qualitative in design, the analytical approaches used varied across the different objectives, a process which allowed for a comprehensive exploration of data (161). Thematic analysis was the primary method for all three objectives, with inductive coding in NVivo, a software for qualitative data analysis. This process followed Braun and Clarke's six step framework for thematic analysis, involving an iterative and rigorous process of familiarization, generation of initial codes, identifying themes, reviewing themes, defining themes and writing up (163). Both inductive and deductive approaches were used in thematic analysis. In the inductive approach, themes were derived from the data, with the questions from the interview guide being used to identify broad topics of thematic interest. In the deductive approach, framework analysis was applied to objectives 2 and 3, where theoretical frameworks guided the analysis and interpretation of findings.

Framework analysis

Framework analysis refers to the process of sorting, organizing, managing and interpreting qualitative data using a relevant theory, model or framework of choice (160). In this study, framework analysis was applied using the Consolidated Framework for Implementation Research (CFIR) and the Normalization process theory for objectives 2 and 3 respectively. For objective 2, the consolidated framework for implementation research was applied after initial coding of transcripts. The CFIR's five domains (innovation, inner setting, outer setting, individuals and implementation process) were used to explore the factors affecting implementation of the E-tick system at different stages (131). Thus, the framework provided a structure for linking the emerging themes from the thematic analysis of transcripts to the broader context of implementation, as well as to guide the interpretation of findings.

In paper 3, the normalization process theory (NPT) was used to identify and understand why some user engagement strategies were successful or not, and the mechanisms behind successful strategies. The theory's four constructs (coherence, cognitive participation, collective action and reflexive monitoring) represent the core aspects determining how well EHRs can be embedded in

health care settings (126). Thus, each strategy identified was evaluated by how the number of constructs it fulfilled. The findings were thus used to write a narrative synthesis, a method used to integrate and report findings from multiple qualitative research sources (164).

The use of both thematic and framework analyses ensured that the study moved beyond description to explanation. By first allowing themes to emerge inductively and then mapping them onto theories (CFIR and NPT), the analysis maintained openness to new insights while also situating findings within theoretical domains. This iterative process allowed the analysis to capture context-specific details from South Africa through inductive coding, while using existing frameworks deductively to systematically link these factors to broader implementation theories.

4.7 Ensuring rigor and trustworthiness

Trustworthiness in research involves ensuring the dependability, credibility and confirmability of research through the use of rigorous and systematic methods to minimize bias and error (164). While there are many ways to improve the trustworthiness of qualitative research, a few approaches were used. To enhance credibility, data triangulation for both objectives 1 and 2, while member checking was applied specifically for objective 2, where the originators where further probed on some of the issues raised by other participants. Additionally, data from objective 1 was reintegrated to further develop and explore objective 2, ensuring greater consistency and depth. In paper 2, the originators responsible for implementing the E-tick system participated in member checking through post-interviews, allowing them to validate findings. For paper 3, independent screening was conducted by three researchers to ensure objectivity and limit bias in decision making of inclusion and exclusion. Moreover, while the rapid review approach was selected for its convenience with time and resource constraints, we acknowledge that this method may limit the depth of synthesis and introduce potential bias. However, to mitigate this, we applied a structured screening process and used established quality appraisal tools (SRQR and CASP). Nonetheless, the absence of cross-checking during data extraction may have introduced subjectivity, which was addressed through supervisory oversight and iterative review.

The use of theoretical frameworks (CFIR and NPT) further improved validity and reliability by providing a structured approach to analysis, ensuring that it remains systematic and grounded in established theory. In addition, this research was conducted under the guidance of two supervisors, which helped to mitigate bias and enhance intersubjective reliability, by ensuring that similar conclusions could be drawn using the same data or methods.

4.8 Ethical and institutional approvals

Ethical approval was obtained from the University of the Witwatersrand Medical Human Research Ethics Committee (M210213). Additional approvals were granted by the National Department of health and the Gauteng provincial department of health (GP_202106_035) and the Ekurhuleni district health committee was granted for the study conducted in the three community health facilities. Informed consent was obtained from all participants prior to participation in the study.

4.9 Researcher positionality

As a researcher, I remained conscious of my biases, assumptions and positionality throughout the study, actively reflecting on how they may have influenced the research. This approach ensured greater objectivity, transparency and reflexivity to strengthen the integrity of the study (159). Recognizing these complexities was useful when navigating multiple constructions of reality and interpreting them without bias, especially given my role as a researcher in interpreting data and shaping narratives.

With a background in social work and research psychology, I acknowledge that my disciplinary lens may have influenced my interpretation of findings. While my training has equipped me with tools to study, understand and interpret human behaviour, these perspectives can lead to biases such as prioritizing certain analytical frameworks over others (165). For instance, my interpretation of EHR adoption may have emphasized user behaviour, potentially overlooking structural barriers which may be equally important.

At the same time, my awareness of broader structural inequalities in South Africa informed my approach to public health. This perspective enabled me to critically examine the systemic challenges within South African health systems, emphasizing social justice considerations rather than just technical solutions.

As a non-South African, I am also aware of the country's unique sociopolitical history and health care challenges. My outsider status may affect my ability to fully grasp the lived experiences of participants, making it essential for me to engage reflexively with the data and remain open to perspectives that challenge my assumptions.

To mitigate some of my biases, I actively built relationships with local stakeholders, carefully listened attentively to their insights, and ensured that their voices were authentically represented in my research. I also sought feedback from some of them to validate my findings.

Reflexivity

Undertaking this PhD journey has been a continuous process of learning and adaptation, shaped by both anticipated and unforeseen challenges. One of the most significant hurdles was the onset of the COVID-19 pandemic which coincided with the early stages of my study in 2020. The pandemic led to substantial delays to my data collection and forced me to adjust my research strategies in several ways. For instance, restricted access to health care facilities made in person interviews difficult, forcing me to rely on virtual interviews for almost a year. However, this approach was not possible with all participants due to digital accessibility issues. Due to the concerns about meeting my data collection targets, I expanded my study by adding a fourth objective, an additional case study on an EHR system. While this data was not included in my PhD, it will be useful as secondary data for a master's student doing researching EHRs. Additionally, some data from objective 2 contributed to my work with the Digital Good project, a collaborative initiative involving researchers examining the ethical dilemmas of digital health innovations in health care settings.

Despite these challenges, this journey shaped my professional and intellectual growth. Initially, my focus was on the technical aspects of EHR implementation. However, through the course of the research, I developed a deeper understanding of the social, organizational, and political

factors that influence the success or failure of such initiatives. I now appreciate how multiple interacting forces can shape the outcomes of EHR implementation attempts.

CHAPTER 5: Exploring the barriers and facilitators to implementing electronic health records in a middle-income country: a qualitative study from South Africa

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Statement of Co-author contributions

Lead author (Candidate - Campion Zharima): The candidate led the conceptualization and study design, conducted primary data collection, carried out data analysis, and wrote the first draft and subsequent revisions of the manuscript.

Co-authors (Supervisors): The supervisors primarily provided guidance on framing the research questions, offered critical feedback on analysis and interpretation, and reviewed and approved manuscript drafts. Their involvement was from the conceptualisation stage up to the publishing of the paper.

Abstract

Introduction: As more countries are moving towards universal health care, middle-income countries in particular are trying to expand coverage, often using public funds. Electronic health records (EHR) are useful in monitoring patient outcomes, the performance of providers, and so the use of those public funds. With the multiple institutions or departments responsible for providing care to any individual, rather than a single record, an EHR is the interface through which to view data from a digital health information eco-system that draws on data from many different sources. South Africa plans to establish a National Health Insurance fund where EHRs will be essential for monitoring outcomes and informing purchasing decisions. Despite various relevant policies and South Africa's relative wealth and digital capability, progress has been slow. In this paper, we explore the barriers and facilitators to implementing electronic health records in South Africa.

Methods: In this qualitative study, we conducted in-depth interviews with participants including academics, staff at parastatals, managers in the private health sector, NGO managers and government staff at various levels.

Results: The Western Cape provincial government over a 20-year period has managed to develop a digital health information ecosystem by drawing together existing data systems and building new systems. However, despite having the necessary policies in place and a number of stand-alone population level digital health information systems, several barriers still stand in the way of building national electronic health records and an efficient digital health ecosystem. These include a lack of national leadership and conflict, a failure to understand the scope of the task required to achieve scale up, insufficient numbers of technically skilled staff, failure to use the tender system to generate positive outcomes, and insufficient investment towards infrastructural needs such as hardware, software and connectivity.

Conclusion: For South Africa to have an effective electronic health record, it is important to start by overcoming the barriers to interoperability, and to develop the necessary underlying digital

health ecosystem. Like the Western Cape, provincial governments need to integrate and build on existing systems as their next steps forward.

Keywords: Electronic health records, implementation, barriers, facilitators, digital health information ecosystem, national health insurance, South Africa.

Introduction

More countries are moving towards universal health care, and middle-income countries in particular are trying to expand coverage, often using public funds. Digital interventions have considerable advantages for both patients and providers through increasing the efficiency of health service delivery and accessibility of health services (166). Electronic health records (EHR) enable monitoring patient outcomes and performance of providers, and so can improve the effective use of public funds (167,168). The World Health Organization highlights that investment towards appropriate digital health solutions such as EHRs is important for low- and middle-income countries due to its potential to enhance delivery of healthcare, improve cost-effectiveness and enable the sustainability of health systems as well as delivering universal health coverage (169).

There has been a growing number of countries implementing electronic health records. By 2011, over 114 nations had initiated their implementation, including middle income countries such as Mexico, China, Brazil and India (76,170). However, many of these efforts are still at an early stage primarily due to financial and technological challenges (44,171). In 2005, the international community, led by the WHO, adopted long term resolutions on implementation of digital health information systems (172). Two of the resolutions were to create an enabling policy environment that supports digital health and encourages governments to invest in digital health solutions, and secondly, to develop strategies to guide implementation (169,173).

In South Africa, in line with the global developments, a National electronic health (eHealth) Committee produced an initial 5-year strategy in 2010, although it was perceived to be too resource intensive to implement (148). A second South African policy, the 2012 eHealth strategy, was developed with a more consultative and iterative process to gather support from

stakeholders (148). This was followed by the 2019 National Digital Health Strategy, which placed more emphasis on digital consumers and the potential of smart devices (169). Both strategies include the resolution to establish a complete electronic health record to effectively measure coverage and monitor service delivery and patient outcomes (142). They both propose the development of a roadmap to guide implementation and the integration of digital health information systems to a shared platform in order to advance functionality and continuity of care (142). In this paper, we report on the South African experience and explore the barriers and facilitators to implementation of electronic health records, to provide insights for EHR implementers in other middle-income countries.

The burden of illness in South Africa, including HIV, TB, violence and injury, non-communicable diseases, and maternal, newborn and child health has a considerable impact on the health and wellbeing of citizens (174). Due to the two-tiered health system, which is divided along socioeconomic lines, there are significant disparities and inequitable access to health care (175). While South Africa allocates more resources towards health than the average of upper middle-income countries (176) and publicly funded health care in South Africa is available to all, its quality still needs improvement (177). Given the country's federal system of governance, the national department of health determines the policy direction, while the nine provinces are responsible for implementation. Recent policy initiatives envisage that a National Health Insurance (NHI) fund will be able to make better purchasing decisions through more formal contracting relationships (rather than through historical allocation of budgets by provinces), and so improve the quality of health services available to the majority (178). While progress towards NHI has been limited, as EHRs are key to monitoring the outcomes of care, they will be particularly important to assess the value obtained by the purchasing decisions of the fund.

Methods

This study adopts a qualitative design, and data was collected during the period from 05 November 2021 to 02 June 2022 with participants working in the field of digital health.

Participants and sampling

Participant recruitment was initially done through purposive sampling and followed by snowballing through referrals from successfully recruited participants. This strategy was adopted in order to source data from specific people with relevant knowledge and experience. In selecting participants through referrals, we specifically asked participants for contacts whose views would differ from them in order to improve sample diversity and minimize bias.

All participants were invited to participate in the study via email, which contained a participant information sheet. Each participant was given a waiting period of one week to respond, after which, two follow up emails were sent a week apart.

Data management

The data collected in this study was kept and stored in a password protected computer in the form of audio file recordings which were saved with generated unique participant identification numbers. We transcribed the audio files using the Otter transcribing software, checked the transcripts for accuracy and coded into themes using the NVivo software. To ensure participant anonymity, personal identifiers were removed from the transcripts and quotes used in reports were checked to make sure they do not reveal the identity of the participants.

Data analysis

All interviews were coded by the lead author (CZ) and themes were identified using thematic analysis following the 6 steps outlined by Braun and Clarke (163). Using an inductive approach, the interview guide was used as a thematic analysis framework where broad topics were identified from interview questions on descriptions of existing digital health information systems, participants' thoughts on digital health policy landscape in South Africa, and factors affecting implementation of EHRs in South Africa. In addition to the list of health information systems provided, further information regarding the purpose, description, development and ownership of each system was supplemented by a separate internet search to provide a more complete picture of some of the existing systems in South Africa. The structure of the interview guide was formulated to explore the vision of digital health in South Africa as outlined by the National Digital Health Strategy, followed by a review of the progress and attempts made thus far with existing

digital health information systems. Lastly, the guide explores the current barriers and facilitators to the implementation of EHRs in South Africa.

During data analysis a list of the names of all digital health information systems mentioned by participants was compiled and additional information on purpose, description, development and ownership was gathered separately through an internet search.

Ethical approval

Ethics approval was obtained from the University of the Witwatersrand Medical Human Research Ethics Committee (M210213) as well as research permission from the National Department of Health, the Gauteng Provincial Department of Health (GP_202106_035) and the Health District research permission for Ekurhuleni and Johannesburg.

Results

Data was collected from a total of 18 participants, mostly based in the Gauteng and Western Cape Provinces of South Africa. Participants were recruited from a range of professions which include: public health specialists from the district (n=2), provincial (n=3) and national (n=3) office of the department of health (n=8), staff from parastatals (n=2), managers and staff from non-governmental organisations and non-profit Organisations (n=4), academics in the field of digital health (n=2) and managers in digital health private sector (n=2).

In the following sections of our results, we describe firstly the policy landscape for EHRs in South Africa, the existing digital health information systems, the barriers and facilitators to implementation, and lastly our participants' views on the potential for EHRs in South Africa.

The policy landscape

The National Digital Health Strategy received positive reviews from most participants: "*I think it [the digital health strategy] is a good policy. I don't think there is anything wrong with the policy*". **(Participant 3)** This support was partly based on the preparatory work. "*From what I've been*

involved in, there were consultations with people that should have been involved". **(Participant 14)**

Others saw the strategy as unfeasible: "*We punch above our weight as a country. We tend to compare ourselves with the developed world in terms of the policies that we put in place, without thinking about what is actually practical. So, we have all these grandiose ideas without the necessary support and infrastructure to actually bring those policies into life*". **(Participant 14)** Others argued that the policies set huge milestones for a 5-year period. "*I think they tend to overreach a bit, because in my experience, the reality is that it takes decades to really put foundations in and get things on the ground. And in a five-year plan you may get similar foundations in place, but you are not going to achieve everything in that time"*. **(Participant 2)**

While the strategy provides a high-level vision of the digital health priorities of South Africa, it does not have detailed guidance on how to move forward: "*The problem with a strategy is it's just a loose and visionary document. It's a great and necessary first step but to derive value from it you need to have a costed work plan with timelines so that people can move along a path to action. Otherwise, it just becomes a talking point and it doesn't really drive any kind of action. The two need to go hand in glove; you need a strategy and then you need the costed roadmap with prioritized action points*". **(Participant 1)** The provincial governments also need to work on tailoring the National Digital Health Strategy to their unique needs. "*It's one thing to have a national strategy but if you want to move forward, you have provincialize it. Not one size shoe fits all*". **(Participant 17)**

Health Normative Standards Framework

One of the key drivers to the integration of health information systems has been the Health Normative Standards Framework (HNSF), which was jointly formulated by the Council for Scientific and Industrial Research (CSIR) and the South African national department of health to enable interoperability of digital health information systems across the country through adherence to its prescribed norms (179). The CSIR is a multidisciplinary research and development organization in South Africa which partners with the government's department of

health among other stakeholders to provide technological expertise, consultancy and support services.

One participant describes how the HNSF was formulated "*It's not something which we pulled it out of thin air, we looked at what is happening in other countries, with the help of the CSIR*". **(Participant 17)** The HNSF thus sets standards for all health information systems including the private healthcare sector: "*There's been quite a large push by vendors, obviously, to capture* [providing a service to] *more organizations because that is part of their business model, that the more records they have, the bigger their footprint. That has been nipped in the bud and the HNSF will prescribe what all health information systems in the country will have to adhere to*". **(Participant 12)** The demands of the private sector vendors and their influence on politicians also needs to be managed: *"The private guys are all trying to sell something, the vendors will be the ones we have to worry about. And the problem is they lobby the politicians. And we just have to be strong enough to say no. If the minister sends somebody to me or comes to me and says that this one said that I just say, no. We have a plan, and we are not being diverted from our plan".* **(Participant 16)**

However, despite the Government's stance on standards for interoperability, there have been engagements with the private health sector: "*The National Department of Health has been exceptionally careful in not alienating anyone or making it impossible to do business in South Africa, because we are trying to engage, and it is a national entity. They are trying to create jobs and to stimulate the economy, which is the overall objective of all departments*". **(Participant 12)** The participant explained how this was achieved: "*they have engaged with the CSIR, which is a parastatal, and it is part of their mandate to facilitate the health normative standards and health information exchange as well as the information systems that would support it*". **(Participant 12)**

Despite acknowledging the importance of the HNSF, one participant points out its shortfall. "*If you look at the health normative standards framework, we don't have all the standards that we need…*". **(Participant 11)** Another participant outlines other challenges: "*The HNSF is not a very useful document in its current form; it's actually just a shopping list of standards. So for me what's*

missing is that middle bit where you have people who understand the architecture and can translate the thing and work closely with people to implement it". **(Participant 2)**

Existing digital health information systems

Most participants said that there has been slow progress in moving towards an electronic health record: "*There actually isn't an electronic health record of any description in the public sector. Certainly, no unifying one. The systems in place are at best patient inventories and accounting systems*". **(Participant 5)** Another participant described the nature of most existing digital health information systems in South African public health care facilities: "*They are more like back entry capture of paper registers. People are capturing information on paper and then giving it to a clerk to type it into a computer. That is not really an electronic health record, where the clinician has access to the digital record and is able to use that during consultation*". **(Participant 1)** In the private sector, the situation is different: "*There is much a higher degree of electronic record and digitization. For example, you get some very sophisticated electronic health records in orthodontics. But there is a very low degree of integration [between providers]. They all stand alone, everyone's fending for themselves*". **(Participant 5)** There is a degree of integration at the funder level*: "because they [providers] are all required to submit stuff to funders. That's why Discovery [a South African private health care insurer] has a fairly sophisticated analyses on large-scale public health trends*". **(Participant 5)**

One participant highlights the failed attempts by one province to implement an EHR: "*Gauteng attempted to do one of those [electronic health record] under an IBM-related system in the past and failed. They tried another one and that failed too. Even to this very day I'm not aware of them having an EHR implemented at Gauteng*". **(Participant 5)** Similarly, in other provinces progress has been slow: "*The North-West doesn't have anything. They've got an accounting system and perhaps a patient inventory. And I don't think anywhere, apart from the Western Cape, has got anything either***..** *In other provinces where I've had some experience, there actually isn't an electronic health record of any meaningful description. This is primarily because nobody can agree as to what the standards should be*". **(Participant 5)** However, provincial governments have

partnered with private sector organizations to implement digital health information systems in health care facilities. One participant highlighted the challenge from their experience working with international firms to implement a health information system: "*It was a company from outside of the country, so they didn't quite understand how the African system works, such as somebody waiting in a casualty for eight hours or … waiting eight months for a cataract operation. [The system] never really worked… although a lot of money was put into it and a lot of workshops were done*". **(Participant 4)**

Participants named several digital health information systems that have been implemented in South Africa. From this information, a list of digital health information systems (Table 1) was compiled, and while this list is not exhaustive, it provides some context for our results. The systems listed include primary health care and hospital information systems. They range from large scale systems that are used nationally and provincially to smaller scale systems used at hospital or clinic level.

Table 1: Digital health information systems mentioned by participants that could provide data for an EHR in South Africa

Type	Name	Purpose	Description	Development/ Ownership
Primary Health care level systems (National)	DHIS - District Health Information Software	To provide a tool for collection, validation, analysis, and presentation of aggregate and patient-based statistical data, tailored (but not limited) to integrated health information management activities.	District health information software is a national open-source health information platform. It moved to become a web based platform in order to make health data available as soon as it is generated.	The project was coordinated by the HISP (Health Information Systems Programme) Centre at the University of Oslo. It was originally developed to capture monthly data for districts in Cape Town in 1998 (152)
	Tier.net	To capture and report adequate data on HIV and TB care and treatment in public health facilities across South Africa.	A stand-alone patient inventory system with clinical information on HIV and TB management in health facilities. It digitizes the records of over 80% of the HIV population in the public health sector. Facilities combine data at district, provincial and national levels and report into the DHIS system.	A software development company (WAMTech) was retained to do the development of the TIER.Net software in collaboration with UCT. The information and data processed by Tier.net is owned by the National Department of Health (180)

Type	Name	Purpose	Description	Development/ Ownership
	HPRS - Health Patient Registration system	To allow identity verification and record clinical visits in public primary health care facilities in South Africa.	The HPRS uses the South African identification number and other forms of legal identification to provide a Patient Registry and offers a Master Patient Index capability. Used nation-wide, it captures patient demographic details only and already has at least 44 million people registered.	This system is owned by the National Department of Health, through its contract with the Council for Scientific and Industrial Research (CSIR) to develop the HPRS (181).
	Electronic Vaccination Data System (EVDS)	To register, record, track and monitor Covid-19 vaccination progress in South Africa.	A national self-registration, online platform, built using HPRS as a base code.	The information and data processed by the EVDS is owned and developed by the National Department of Health. The department works with a team of staff, health care workers and private service providers who interact with the data (182).
Primary Health care level systems (Provincial/District)	Primary Health Care Information System (PHCIS)	To centralize the registering of patients and record keeping by catering for entry of patient data, capturing of patient assessments and tracking of patient visits and outcomes.	A basic administration system that was integrated with other modules for Obstetrics and gynecology, booking and appointment as well as HIV and TB monitoring. It has been implemented in all public sector primary healthcare sites in the Western Cape except the City of Cape Town.	The system is owned by the Western Cape provincial government and was developed for public-sector community health sectors and clinics in the province. It provides demographic data for patient visits by using a unique patient identification number (administered by CLINICOM) that is attached to a patient's paper record as a bar code (150).
	E-tick	To record and store patient information regarding their visit to a facility. This information includes names, dates, illness and treatment and service provided at the facility.	An electronic/digital version of the paper tick register used to record patient data by health care providers and administrators. It has only been implemented in the Ekurhuleni district of the Gauteng province. The e-tick software is accessible using desktop computers or tablets.	The development and implementation of this system was funded by the Aurum Institute, an organization that partners with government, private sector and civil society for community health interventions.
Hospital Information Systems	Meditech	To document patient symptoms, diagnoses, comorbidities and medical history.	An electronic health record system which connects to other operational systems such as imaging, lab and pharmacy.	Meditech South Africa (Pty) Ltd is privately owned software which provides software solutions to healthcare organizations in South Africa (183)

Type	Name	Purpose	Description	Development/ Ownership
	Medicom	To integrate data captured in Patient Registration, Appointments Scheduling, Out-patients Management, Trauma, In-patients Management, Medical Records and Patient Billing by health care professionals.	An integrated on-site electronic medical record system.	Privately owned by software vendors (184)
	Clinicom	To provide patient demographic and hospital administration data.	It is a system that supplies a unique patient identification number that is shared across other systems for public-sector users throughout the Western Cape. This system is now used in at least 52 hospitals across the province.	Privately owned by software vendors. This is used by nearly all hospitals in the Western Cape, providing patient demographic and hospital administration data (150,185)

National and provincial systems

Table 1 shows health information systems by scale such as national, provincial, district and hospital information system. The District Health Information System (DHIS), Tier.net, Health Patient Registration System and the EVDS are core national systems used across South Africa. The National Department of Health has been involved in the development, implementation and ownership of numerous digital health information systems through collaboration with other stakeholders: "*Currently, we [Department of Health] are running I think twelve systems nationally under CSIR*". **(Participant 6)** There has been an attempt at integration especially for systems that have a shared purpose, although the envisaged solution seems to be merging two systems in to one, rather creating an eco-system where different systems can speak to one another: "*The problem is that in the migration of data from the TB electronic register to TIER, there's been many challenges which are yet to be resolved. One is the capacity at Provincial and District level, and that National has not put in place a sufficient number of people to do the troubleshooting*". **(Participant 3)** Some participants mentioned the potential to build on the success of the Electronic Vaccination Data System (EVDS) developed in response to the COVID pandemic: "*The biggest single thing in health records nationally is something no one was even thinking of eighteen months ago, and that is EVDS, which currently has I think sixteen million people registered. That data just didn't exist before*". **(Participant 8)** Another participant highlights one of the reasons for

its success: "*There was support throughout. Firstly, they got the change management process right. We received one training from one source. I think that was the starting point that I feel was correct. The training management, they've done it perfectly*". **(Participant 6)**

The Western Cape Provincial electronic health record ecosystem

The Western Cape Province has been able to build a coordinated digital health ecosystem. Initially, the province implemented a hospital information system: "*The primary one was the Clinicom System which has a patient master index and was implemented in all hospitals. We began to use it as the Primary Index for the Province, it was largely administrative but with little clinical data. Linked to that is the Pharmacy System which looked after stock management and dispensing, and it now runs in all hospitals, most community health centers and some clinics. There was a billing system that was also linked to Clinicom*". **(Participant 2)** In addition to this, the provincial government further implemented a primary health care system: "*We [Western Cape] implemented the primary healthcare system that we wrote ourselves which collects clinical information for visits [patient-clinician consultations] and does appointment scheduling and reporting. Then we did other systems, a forensic, a mortuary system and emergency medical and a picture archiving and communication system and radiology information system [PACS/RIS] which were all linked*". **(Participant 2)** This enabled interoperability, sharing of health information across facilities and platforms in the province: "*So there is one coherent provincial health record that links the clinical record to national lab results to reporting into [District Health Information Software] DHIS2, reporting to donors, to specific campaigns like HIV and non-communicable diseases*". **(Participant 8)** As a result of this work, the province can track patients and monitor large scale public health issues: "*We are reaping the benefits because these systems are part of the twenty plus systems that are pulled into the provincial health data center. We can link the data on individual patients and come up with a longitudinal health record. They can do disease cascades and infer disease or condition episodes*". **(Participant 2)** The success of the Western Cape owed much to the steps that were taken by the provincial government to build a digital health information ecosystem, making progress faster than other provinces as one participant points out: *"Out of 55 hospitals in the Western Cape, 54 of them have electronic health records.*

In Gauteng we have 37 hospitals, but only two hospitals have them. We have about 20 plus community health centers [in Gauteng] and only two community health centers have implemented them". **(Participant 17)**

Hospital Information systems

Participants mentioned hospital information systems which include Medicom, Meditech and Clinicom. Such hospital systems are often privately owned and developed to cater for the targeted needs of hospital operations. While the purpose and design of each system may depend on the needs of the health care facility, hospital systems generally have a transformative impact on clinician workflow as one participant points out: "*Back in the day we didn't have such things as tablets and handwriting recognition or anything like that, so it was largely to capture an image rather than some sort of auto-recognition or the other horrible case of data capture by typing*". **(Participant 5)** However, the implementation of hospital systems may have different impacts on different types of clinicians as one participant highlights: "*It is much easier for the pharmacists and the lab people who seem to be drawn to that much more readily. In radiology or imaging per se …. your metadata can be captured quite easily, with all the picture archiving systems these days*". **(Participant 5)** However, the successful implementation of hospital systems requires the cooperation of the users: "*The greatest challenge is getting clinicians on board, who don't relish writing notes and capturing information. They feel in one sense that they're above that … You have to either insist or demonstrate the benefits of their information going in and what they get out, so that they don't feel like they're just data capturers*". **(Participant 5)**

Factors affecting EHR implementation

Participants identified critical factors for the implementation of EHRs in South Africa and brought attention to four main issues that need to be addressed namely; (a) leadership, (b) skills and expertise, (c) resources, funding and infrastructure, and (d) governance.

Leadership

Leadership is viewed as an important factor in facilitating implementation: "*You need strong leadership really and everybody to buy in because it's in our collective interest".* **(Participant 3)** One participant highlighted the role played by leaders when implementing at scale: "*I think the first barrier is understanding the scale and having high level buy in from the minister of health. I'm not saying that isn't present, but I don't think they have always understood the full project and the implications of taking on something like that if you're talking about national implementation".* **(Participant 1)** Having high level buy-in also improves long-term collaborations with stakeholders as one participant shared their experience of the Western Cape Province: ***"****It's a matter of getting everyone on the same page. In the Western Cape I'd say the relationship between Provincial Government and University of Cape Town is pretty good, because we've had a long-standing collaboration and sharing of skills. [As a result], the Provincial Government had an openness to allow certain things, and I was able to deal directly with the Head of Department [Western Cape provincial government] and the Deputy Director Generals".* **(Participant 2)** However, the lack of high level buy-in from organizational leaders in some cases led to a reduction in the available support to government: **"***the decision was to get rid of Digital Health [unit] and that included my division and several others including Telemedicine [at the Medical Research Council]. So that was a real setback because after that there was a complete gap".* **(Participant 2)**

Part of having good leadership requires putting the right people in place to lead and facilitate implementation. Participants criticized the appointment of leaders based on their membership to political parties at the expense of merit: **"***I think the problem is [we] have people in positions of power that are there because [of their political connections], not because they were good logistics people or because they understood technology or anything else".* **(Participant 9)** Others highlighted how the Western Cape Province has been able to make greater progress: "*The WC [Western Cape] Government does seem to a greater degree to get on with being a government as opposed to pushing party lines and deploying party cadres. And that's probably why they're a little further along; there is a sense of it is less about party politics and more about actually delivering as a government"*. **(Participant 5)**

Although the National Department developed the National Health Normative Standards framework to establish an overarching vision to integrate health information systems, internal conflict was noted: *"There is a lot of uncertainty in the Department about what belongs in the Department and what would belong in the NHI environment and in the NHI Unit. So, whether it's information systems or electronic systems and the rest of it, that is all up it the air at the moment and because the Deputy Director General that was hired to do NHI is now the Acting Director General, and he has even less time and bandwidth to focus on anything other than the crisis the Department is currently facing"*. **(Participant 3)**

Skills and expertise

Participants argued that capacity building is an essential part of the process: "*Part of any comprehensive strategy to implement electronic health record needs to have a strong capacity building component".* **(Participant 1)**, and that South Africa has people with the right skills to lead implementation: "*We have very knowledgeable people in the private information systems supplier domain. There are very knowledgeable people in the NGO domain. There are very knowledgeable people in the private healthcare sector, private hospitals, private funders".* **(Participant 11)** However, other participants said that the skills necessary are in short supply in government: "*We don't have skilled staff [in government] and we don't have budgets to hire skilled staff".* **(Participant 1)** Skilled people can be outsourced: ***"****We need to have a partner that we can work with to bring lots of IT skills, as a next best option, of course. The best option [though] is to have [the skills] in house".* **(Participant 15)**

Participants noted the challenges when recruiting for the public health sector: "*People are now reluctant to go work in the National Department for a number of reasons. One is they scared they going to be embroiled in controversy and their personal integrity might be at stake. The second is that the Department doesn't pay as well as the private sector. So, attracting the right people is a big challenge and getting them to stay is also a big challenge".* **(Participant 3)** However, without sufficient skills, there may be limited progress: ***"****If we do not bring in people that have the necessary skills to do the job, then we're always going to remain behind, as in other parts of the country".* **(Participant 14)** The National Department of Health needs to build a critical mass of

people: *"You need to create specific job categories for health information system workers inside the ministry of health and recruit people into those positions who have got some basic training and then send them on specialized training".* **(Participant 1)** A provincial health official added that the Department of Health needs to create job roles that involve clinicians: "*Chief medical information officer is the way to go. You should have clinicians running information systems".* **(Participant 17)** One participant points out why this is important: "*So often the people that decide on systems are not the people that use the systems. So, the decisions are often taken by people … who do not understand the needs of the user. They go out and procure systems without realising that they're not solving the problems that the users had in the first place. And so, what you have is a system that's not really useful to the user, but useful to you as a policy maker. So, they [users] won't support it, because it's not useful to them, why should they implement it?"*. **(Participant 15)**

Participants highlighted the necessity of having a highly trained health care workforce for this vision: "*So there must be a lot of training. Among the nursing staff computer literacy is really not that great. That needs to be fixed".* **(Participant 4)** Training needs to start early and accommodate everyone that joins the public health workforce: "..*starting with training people at Universities. Pre-service is as important as in-service training. But training is an ongoing thing, I mean, it's not a once off. It's a continuous thing".* **(Participant 3)** The failure to train and prepare the workforce may lead to some problems as one participant pointed out: *"Our biggest challenge in the modern era is the human factor, in breaches of privacy through inadvertent sharing of data and access to systems, being hacked and being conned into security breaches. The systems are pretty much sewn-up with encryption, protection, back-up, data security, disaster recovery, but they're only as strong as the weakest link, which is us humans"*. **(Participant 5)**

<u>Resources, funding and infrastructure</u>

Participants argued that digital health information systems require significant investments for infrastructure: "*Our government is not doing enough in rolling out fibre. We rely on secondary infrastructure like Vodacom, or MTN [private sector companies] with whom now we have contractual issues".* **(Participant 6)** Much of the plans to develop a digital health eco-system are hampered poor connectivity: *"we can't do what we need to do. Nearly 40% of public health facilities have no reliable connection to the internet. How do we run a real time data system that's*

trying to run the national health insurance with portable health records?". **(Participant 16)** Moreover, due to the currently inadequate rollout of infrastructure, there are geographical disparities: "*In the remote clinics, it'll be a while before we get an integrated patient record that is operational".* **(Participant 16)** There is also insufficient resources to purchase both the hardware and the software: "*We need to source money for enablers. You can't think of buying and developing software systems if we know we're not going to have money for hardware… Often you have hardware, but you don't have system to load onto the hardware. And other times, you have software, but you don't have the hardware. [For example] there was a problem, and they ended up just giving computers to clinics, and by the time they return with software, the computer will be gone (stolen), because it was sitting in a box"*. **(Participant 15)**

As part of the infrastructural needs, one participant highlighted how the challenges related to the lack of storage facilities that are owned by the national department of health: "*We also have storage issues. Right now, as a department we are renting under Microsoft cloud".* **(Participant 6)** Another participant further illustrates the importance of investing towards a data repository system towards the integration of systems through a central data storage centre: "*The other problem is that we have 10 departments of health, a national Department of Health, and then nine provinces, and they're all autonomous, but they don't have their own data centers, they all can run whatever they want to run. As a result, it's really hard to do any kind of migration of data to a central data repository*". **(Participant 9)**

One participant highlighted the importance of assessing what resources are needed in different areas of the country: "*There must be a proper situational analysis done on what is available. It's a massive job so maybe it would be good to cut it down to just the Metros first and then from the Metros do the big municipalities".* **(Participant 4)** It was suggested this should be followed by a costed work plan of the budgetary needs and a phased implementation would allow an adaptive learning experience: ***"****You could take it [implementation] in stages. Definitely. You do well in one area, one local area and then you replicate that. By the time you start replicating it, you may have better ways of doing things".* **(Participant 2)**

Despite the need for more resources and better infrastructure, one participant argued that a lot can be achieved with the digital health information systems that are already in place: "*We do not*

need something that is expensive. I think EVDS proves us wrong, in terms of wanting fancy systems. We need something where we can scale it up when you add in modules. You do not have to add it up all at the same time, only gradually". **(Participant 6)** Another participant suggested that given the shortage of resources: "*the first thing to do is to actually see if you can utilize your existing resources [infrastructure], and only add more when you need them".* **(Participant 13)**

Governance

Due to South Africa's federal system of governance, the national department of health has limited influence over provincial decisions, but: "*making sure that there is sufficient alignment of vision between national and province is absolutely critical. Otherwise, it will just not work".* **(Participant 15)** A former national health official explained further: *"We've tried centralisation for setting norms and standards but if the money is not in the same place when you are setting norms and standards, nobody listens to you".* **(Participant 3)**

Purchasing is done through a tender system, and one provincial health official pointed out how the tender system is often loosely followed and not monitored by responsible officials: "*The tender system is open to abuse. Who monitors whether a deadline is met? What is the consequence (of not meeting a deadline)?"*. **(Participant 4)** A poor tender system can lead to a negative reputation on the department of health: ***"****As a consequence [of corruption], the perception is that you can't trust the National Department any longer. No one is going to give the National Department a big pot of money to run a tender until it can show that it's got the systems and people in place who can do this thing without losing the money".* **(Participant 3)**

However, one participant complained that the tender system didn't identify the right people to work with the department of health: ***"****The whole tendering system is not good. I've got a bunch of colleagues that I've worked with, over the last 20-30 years, that I trust, that I know that they can do what they say they're going to do. But the process doesn't allow me to even pick up the phone and speak to the guy. I have to go on a public website and get three quotes from arbitrary people that I have no relationship with. It's like an arranged marriage".* **(Participant 9)** While it is not appropriate to recruit one's colleagues, the process needs to ensure that skilled companies are willing to apply by providing technically adequate terms of reference, briefing sessions, and

building confidence that the government will play its part appropriately, all of which require experienced people with skills and integrity in government: "*You can avoid it [corruption] if you have people with integrity running the system. If you have people of dubious levels of integrity, then you won't necessarily get the best system. It starts there unfortunately. You've got to get people with integrity".* **(Participant 3)** One participant argued that transparency and openness is important: "*There are established ways to procure and help one avoid the pitfalls of corruption, because it is a complex task. I would think it would be a good idea to set up a transparent panel of experts to assist with selection and with making those choices*". **(Participant 1)**

Table 2: Summary of factors affecting EHR implementation

Factor	Details
Leadership	• Leaders that understand the scale of implementation, and obtaining buy in from various stakeholders for a collaborative implementation process. • Leadership appointments based on merit rather than political affiliations. • Internal conflicts leading to uncertainty and hindered progress.
Skills and expertise	• Capacity building to address skills shortage in the public health sector, collaborating with more skilled sectors can be helpful • Health care workers should be involved in the implementation process • Early training programs can prepare the health care workforce for implementation.
Resources, funding and infrastructure	• Long-term investments towards infrastructural needs (hardware, connectivity etc.) • Increased funding for public health facilities in remote areas. • Setting up data storage centers to facilitate the integration and migration of health data. • Building on existing infrastructure while gradually upscaling.
Governance	• Alignment between provincial and national health departments for concerted implementation, transcending the federal system. • Better monitoring mechanisms for tender systems in to combat corruption and improve accountability. • Appropriately qualified and skilled authorities to prioritize digital health. • A transparent and multi-disciplinary panel of experts to help with planning and decision-making.

The potential for electronic health records in South Africa

Participants shared their thoughts on the potential for EHRs in South Africa, addressing the country's current position and the practical steps for advancement. One participant pointed out how South Africa is well positioned to make advances in digital health: "*Compared to the rest of*

Africa, South Africa is quite confusing. Clearly it has more resources, people, companies, NGOs and university involvement. However, that doesn't necessarily make things more coherent because there are many separate, often parallel, sometimes competing, different health information systems". **(Participant 8)** The history of how health care has been funded in South Africa increased the fragmentation: "*What happened in South Africa is that you had disease programs that had funding and they had their strategies for their own. And so, they started implementing digital solutions. And then they were driving those things. And there wasn't a strong body at the top saying hang on, we need to co-ordinate all of this in terms of the Digital Health Strategy*". **(Participant 2)** One participant gave their account of how attempts at national leadership had failed: "*The implementation of the strategy should obviously be led by the NHISSA [National Health Information Systems Committee of South Africa] but it became weakened and there were these other programs that became stronger. There was fragmentation with power struggles within the Ministry. Despite the strategy being ambitious, certain things could have still been done if there were resources and the right people were in place to drive things through*". **(Participant 2)**

Although relevant skills are available in the private health sector, participants described their concerns over the poor relationship between the National Department of Health and the private sector: "*In South Africa it has been particularly difficult for the public and private sector to partner for many reasons. The private sector tends to be focused more on billing systems and practice management systems that are focused more on their business model, where the public sector is focused more on public health, and to some extent the longitudinal patient record that is emerging now".* **(Participant 1)** A former national department of health official attributes the poor relationship to a lack of trust between the public and the private sector: **"***Relations are not good. They are awful. There are exceptions but I'm talking generally now. There's no trust between the public and the private sector."* However, collaboration is still necessary for progress to be made: "*There has to be a dialogue between policy makers, researchers, community members".* **(Participant 3)**

One participant argued that there are two possible approaches to implementation: "*Many countries have implemented electronic health records without first having a strategy. Although*

it's ideal if it's implemented as part of a strategy, I don't think it's a necessary first step. So, some countries start top down, starting with a strategy and then implementation after while others start bottom up, starting with implementation then developing the strategy after. I'd say most countries follow the bottom-up approach". **(Participant 1)** The participant argued that most countries let different systems develop on the ground based on need, while ensuring interoperability, rather than trying to impose a single system from the top.

Other participants agreed, arguing that South Africa could move towards building a digital health ecosystem for EHRs by making use of existing systems: "*We can build off what EVDS has done. It's limited in many respects, but it's done the job in terms of getting patient level data and data by admission, gender, medicines and outcomes...Take all that exists across all the hospitals, build on that and move on as long as it's operable and the key word is inter-operability…I think they may have multiple entry points. You just have to agree nationally on what needs to be done and go for it*". **(Participant 3)**

Discussion

Our findings show that while South Africa has the necessary policies in place, little progress has been made to develop the necessary digital health ecosystem for a national electronic health record. Several e-health systems are currently deployed in different facilities across the country, but the integration of these stand-alone systems remains a challenge in most parts of the country. However, the Western Cape Province, over a 20-year period, was able to draw together data from existing data systems, and build new systems, which led to the creation of a provincial digital health eco-system and EHR. Much of this progress has been attributed to consistent and high-level political support and sufficient technically capable staff both inside and outside government. In contrast, other South African provinces are struggling with a lack of national leadership and conflict, a failure to understand the scope of the task required to achieve scale up, insufficient numbers of technically skilled staff, failure to use the tender system to generate positive outcomes, and insufficient investment towards infrastructural needs such as hardware, software and connectivity.

The WHO recommended that developing countries establish multi-stakeholder steering committees to help determine what is available in their country and undertake the suitable planning and development processes (186,187). However, many middle-income countries like South Africa have also struggled with interoperability after implementing various digital health information systems.

India first published their national standards for EHR adoption, and then convened an expert committee established to support the adoption of EHRs (188). However, uptake of the EHRs was slow primarily due to the lack of universal patient identifiers, which affected the accurate coordination and integration across different systems. Similar to South Africa, India provides its citizens with free health care at government health facilities in order to address the challenge of financial vulnerability faced by over 40% of the country's population, as a step towards universal health coverage (188). EHRs in India are fragmented as the country still needs to address key issues such as improved infrastructure, a policy landscape, training for healthcare professionals and increasing partnerships between private and public health sectors (189). As reported in our findings, similar issues need to be addressed in South Africa for a successful EHR implementation.

China began by implementing regional EHRs with unique patient identifiers, followed by a series of guiding standards for interoperability (189). In its implementation, China followed Australia's 3-stage approach which begins with the piloting, followed by regional implementation and national EHR system, allowing both local and international vendors to provide solutions at different stages (190). Thus, with a universal patient identifier and interoperability standards in place, a regional and phased implementation of EHRs was the strategy used by China. However, nationwide interoperability is still poor despite the country's relative success with regional implementation of EHRs, and this is due to the lack of a national strategy for establishing standardized EHR systems until much later (188).

Brazil made notable progress in EHRs from as early as 2011 when the country initiated a national health card to establish a unified health record for citizens, followed by the provision of technical support and resources for EHR implementation in primary care facilities (188). As a result, different states and municipalities began using various information systems since the late 1990s, leading to challenges in integration to form a national electronic health record (191,192).

However, in 2019 Brazil implemented a National Health Data Network, a platform designed to enable the exchange of information across facilities in health care networks in both public and private sectors, creating a viable solution for their interoperability challenges.

In contrast, the lack of a proactive approach and commitment to dedicate resources towards the advancement of EHR adoption has slowed down South Africa's progress. Several studies show the importance of interoperability in addressing the fragmentation of digital health information systems (9,193,194). Given the current progress of the Western Cape Province in building a digital health ecosystem, other provinces in South Africa can identify the strategies used and challenges faced to draw insights that can guide implementation in other regions. To address the problem of fragmentation in South Africa, charting a path forward involves building on the existing health information systems. Widely used, population level systems such as the EVDS or the Health Patient Registration System (HPRS) are essential starting points for integration of systems (156). Out of the nine provinces in South Africa, five of them have some kind of operational EHR system in public hospitals (150), but some are from different vendors and built on different architecture, making it difficult to share information between healthcare facilities (195).

Participants highlighted the challenge of data storage and how the department of health needs a central data repository which is essential for the successful integration of health information systems. Some studies have shown that cloud based EHRs may offer a solution to data storage problems with lower costs, greater reliability of power supply, ability to facilitate much faster interoperability and greater analytical computing power (196–198). Concerns about data protection and cyber security can be met by ensuring that the servers providing the cloud-based services are located in a jurisdiction with at least the same, but preferably stronger, regulation of such issues.

It is evident that while South Africa has the necessary policies in place, the progress in implementing electronic health records has been limited. As described above, other middle-income countries have encountered challenges similar to what South Africa is facing. However, overcoming these challenges would require overcoming the barriers and drawing lessons from successful examples such as the Western Cape Province and from other middle-income countries

and guiding the country towards a digital health ecosystem and an electronic health record system

Limitations

Due to the use of snowball sampling technique in this study, representativeness was not guaranteed as participants were nominating people they know and those who are also likely to share the same views with them. To mitigate this issue, we specifically asked for contacts of participants whose views would differ from other participants to improve sample diversity.

As data collection was conducted during a period of Covid-19 lockdowns, many health professionals were busy attending to the pandemic. As a result, some health professionals who may have had valuable insights could not participate in the study.

Conclusion

South Africa plans to introduce the National Health Insurance to facilitate universal health care, and electronic health records are an integral part of this vision - to register and monitor patients who make use of the health system. However, developing a digital health ecosystem for an electronic health record requires long term commitment, adequate funding, critical skills and expertise and leadership that prioritizes and addresses digital health needs.

CHAPTER 6: Exploring the factors associated with the stalled implementation of ground up EHR system in South Africa: insights from the E-Tick case study using the consolidated framework for implementation research (CFIR)

Statement of Co-author Contributions

Lead author (Candidate - Campion Zharima): The candidate led the conceptualization and study design, conducted primary data collection, carried out data analysis, and wrote the first draft and subsequent revisions of the manuscript.

Co-authors (Supervisors): The supervisors primarily provided guidance on framing the research questions, offered critical feedback on analysis and interpretation, and reviewed and approved manuscript drafts. Their involvement was from the conceptualisation stage up to the publishing of the paper.

Abstract

Background: Electronic health records (EHRs) have the potential to improve service delivery through record keeping and monitoring health outcomes. As countries move toward universal health coverage, digital health tools such as EHRs are essential for achieving this goal. However, EHR implementation in middle income countries like South Africa faces obstacles. This study aims to explore the reasons behind a stalled implementation of the E-tick system (an electronic version of a paper primary health care register to record services provided), using the Consolidated Framework for implementation Research (CFIR).

Methods: Using qualitative design, in-depth interviews were conducted with 38 participants to explore their perceptions and experiences, and the factors surrounding E-ticks success and stalling. Participants included managers, stakeholders, implementers and end users from the 3 implementation clinics. Data was collected using semi-structured interview guides. Thematic and CFIR framework analysis (innovation, inner setting, individual characteristics, implementation process and outer setting) were applied.

Results: The E-tick system was designed to improve data quality in paper health registers, addressing inaccuracies in reporting to district and provincial health departments (Innovation domain). Implementers iteratively developed the system through user input from managers and clinicians, and stakeholder engagement of software developers, funders, health managers and decision-makers from the provincial health department (individuals characteristics). Although the system was initially well adopted by end users, it stalled primarily due to outer setting factors, which included a change of developers, funding cuts, and limited support at provincial health department level due to capacity gaps, political appointments and mistrust stemming from corruption and abuse of the tender system. Moreover, resistance to leveraging lessons from locally developed small-scale systems further constrained institutional support for the E-tick.

Conclusion: Although successful implementation of EHRs can be facilitated by strong user engagement and co-design, outer setting factors such as governance, funding and policy alignment can pose significant threats to sustainability. This underscores the importance of effective synergy between top down and bottom-up processes for successful implementation.

Keywords: Electronic health records, implementation, barriers, facilitators, Consolidated Framework for Implementation Research (CFIR).

Introduction

Electronic health records (EHRs) hold the promise of improving service delivery, monitoring and evaluation of health interventions and record-keeping for public health (199). As more countries work towards universal health coverage, leveraging digital health tools like EHRs becomes more important for enhancing service delivery and improving quality of care (76,168). The World Health Organization's global digital health strategy emphasizes the need for accelerated adoption of EHRs to achieve health goals (169). However, EHR implementation in many middle-income countries remains slow due to financial and technological challenges (200).

Implementing EHRs is an evolving process that requires adaptive and context specific policies to meet ever changing needs (201), and a clear vision to move from pilot to scaled implementation (76). In some high-income countries where implementation has occurred (80), a 'top-down' approach was often used, with systems pre-configured and users required to adapt. Although this offers coordination and central oversight, it can limit flexibility. In contrast, bottom-up approaches emphasize co-design with end users and adaptation to local workflows, which often enhances usability and adoption (202). Research suggests that successful EHR implementation in complex health systems requires balancing national coordination with local innovation, as this allows centralized oversight, while engaging local health communities and tailoring systems to user needs (202,203).

South Africa has made policy advances such as the national digital health strategy (2019-2024) (142), with considerable resources as a middle-income country and sufficient technical expertise, but progress toward a national EHR has been slow. This is because policy direction and technical capacity are sometimes impeded by systemic and political barriers. Within this context, most primary health care facilities continue to rely on manual paper-based systems which are labor intensive and prone to errors in data collection (204,205). However, bottom-up efforts have been made to improve data quality and accuracy. These include Tier.net, an electronic record system used with patients living with HIV/TB and E-tick, the electronic record system we studied. The E-tick is a digital version of the tick register, a book in each healthcare facility for recording patient

attendance and care delivered. In this paper, we use the Consolidated Framework for Implementation Research (CFIR) to explore an attempted implementation of a the E-tick system, very similar to an EHR, examining how its implementation stalled despite a consultative approach in its implementation.

Background

Digital health policy in South Africa

As a middle-income country, South Africa has made policy strides in line with the global developments, which should facilitate the adoption of EHRs, such as the National Health Act 61of 2003 and the National Digital Health Strategy (2019-2024) (142,206). The Health Act outlines the role of the National Department of Health in coordinating health information systems across national, provincial and district levels (142). Although policy direction is set at national level, the federal system means that provinces can independently determine their own healthcare spending. Therefore, implementation largely occurs at provincial and district levels, with each maintaining its own health information systems within the national framework. This provincial autonomy has contributed to fragmentation, as different provinces and regions develop EHR systems through separate procurement processes (207). This fragmentation is further compounded by a political economy of procurement, in which tenders are prone to corruption, mismanagement and the absence of oversight structures (208). These factors directly affect which innovations are funded, how resources are distributed and whether systems can successfully reach scale, as funding decisions often prioritize large-scale centralized systems.

South Africa uses two health information systems in public sector: the Health Patient Registration System (HPRS) and the District Health Information Software (DHIS) (153). The HPRS is a manual patient registry which records patient contact details as well as legal identification numbers, while the DHIS is an electronic system used to collect aggregated data on services provided to patients in public health facilities (209). The DHIS data is first collected manually, then captured into the DHIS software where it is submitted to the district, then provincial and national health departments. The method used to record primary health care data is a tick register, a manual paper-based system where clinicians mark or tick off the services provided in a large logbook with

columns for dates and types of services offered (antenatal care, vaccinations or chronic disease management). However, this process can be arduous, time consuming and prone to many recording errors. Studies evaluating the District Health Information System (DHIS) have confirmed persistent data gaps, citing poor documentation, manual entry under heavy workloads, and errors as major contributors to discrepancies (210).

South African health system

South Africa plans to implement a National Health Insurance Fund, to facilitate better purchasing decisions through more formal contracting relationships rather than the historical allocation of budgets by provinces (45). In this case, EHRs are key in monitoring patient outcomes and assessing the value of care purchased. Although most provinces have had some type of operational EHR system in public hospitals (150), there is no national EHR at primary care level and different architectures still pose a challenge to their integration for nationally coordinated use (195).

Provincial health departments in South Africa are often run by political appointees, who work under directives from their affiliate political party. This has led to pervasive corruption in the country's health system, which has been reported at various levels of government (211). For example, 150 million rand awarded to a communications company during the COVID pandemic was misappropriated, and the health minister was suspended as a result (212). In another case, the provincial chief financial officer who exposed a 1-billion-rand tender fraud was assassinated (213). Such cases illustrate how poor financial management systems and political appointments enable corruption, which act as impediments to the public trust in the health system (214). For digital health innovations, such dynamics increase the risk that systems are chosen for political or financial interests rather than their impact or merit, which affects the health department's ability to work with other stakeholders, or source funds for large scale projects, including to projects to implement EHRs. Moreover, the absence of countermeasures such as accountability and transparency, it becomes difficult to implement large scale projects like EHRs.

The E-tick system

An electronic version of the paper-based tick register (E-tick) was developed and piloted in 3 public health care facilities in Ekurhuleni district starting in October 2017. Clinicians record services provided directly into the digital system on a patient's record which also allows facility managers to monitor daily activities such as headcount and services offered. Although this is not a full EHR, the system can be expanded to include diagnosis and lab results, and to integrate with other systems that are currently used in public health facilities. Against this backdrop, the E-tick system sought to provide an alternative that could improve data accuracy at the facility level while feeding directly into the existing provincial and national reporting systems. However, such progress is dependent on not only user adoption factors but also broader contextual dynamics (215). Thus, by situating the E-tick in relation to both micro-level realities and macro-level policy and political economy, we aim to provide more holistic understanding of why grassroots digital health interventions may stall or fail.

Consolidated Framework for Implementation Research (CFIR)

Implementation research seeks to understand why some implementation efforts succeed and others don't, and the role of the context (216). To explore the key factors affecting implementation in our case study, we employed the consolidated framework for implementation research (CFIR), which integrates existing theories of implementation and behaviour change into a unified framework (217). The CFIR is a meta-theoretical tool with standardized constructs to examine enablers and barriers to implementation across different stages (pre-implementation, during implementation and post-implementation) (218).

The CFIR was developed through a review of published theories and reports on factors influencing implementation (219). Hence its strength lies in its broad applicability and potential for generalizability, which are useful for informing practice across diverse settings. The framework has 5 broad domains (see Table 1), which include: innovation domain, inner setting domain, outer setting domain, individuals domain, and the implementation process domain, which together capture multilevel determinants of implementation (131). Due to the

framework's flexibility, researchers can tailor it to specific interventions and contexts (220), And it has been widely adopted in research, applied across different research designs, and cited in over 300 published articles (218). Recent updates have been made to the framework, using responses from authors who used the framework, leading to refined construct names and definitions to make them more encompassing (131). In this paper, we draw on the updated CFIR to guide both our analysis and reporting of findings.

Table 1: CFIR domains by Damschroder et al., (2022)

CFIR domains	Definition
Innovation	• The "thing" being implemented, such as a new treatment, program, or service. • Key factors that affect innovation include its source, evidence base, advantages over existing practices, adaptability, trialability, complexity, design, and cost.
Individuals	• The roles and characteristics of people involved in innovation. • Key roles include high-level leaders, mid-level leaders, opinion leaders, facilitators, and implementation teams who guide and support the innovation. • It also highlights innovation deliverers and recipients.
Inner setting	• The environment where an innovation is implemented, such as a hospital or school. • Key elements include structural characteristics like physical and IT infrastructure, work organization, and staffing levels.
Outer setting	• The broader context or setting within which an organization or project operates, such as a hospital system or school district. • Factors influencing implementation in the Outer Setting include large-scale disruptions, local attitudes, socioeconomic conditions, external partnerships, and regulatory policies.
Implementation process	• The activities and strategies to introduce and sustain an innovation. • Key components include forming teams to collaborate on tasks, assessing the needs of both innovation deliverers and recipients, and evaluating the context to identify barriers and facilitators. • Planning, tailoring strategies, engaging participants, testing small-scale changes, and reflecting on outcomes are critical steps.

Methods

The study adopts a qualitative design to explore the perceptions and experiences of stakeholders, managers, implementers and end users of the E-tick system.

Participants and sampling

We recruited a total of 38 participants, categorized into three categories: 1) managers and stakeholders, 2) implementation team and, 3) end users. The senior health managers and external stakeholder's category includes decision makers and higher-level people who were not directly involved in the system's implementation but provided insights into the context and the decisions impacting it. The implementation team comprised individuals who were responsible for initiating and deploying the system and introducing it to the users, while the end user team consisted of the clinicians and managers from 3 recipient facilities. Participants from the managers and stakeholders as well as the implementation team were purposively selected through referrals from key individuals and recruited via email. For end users, a convenience sampling was used, with the researcher recruiting available users who were available, with the aid of gatekeepers during visits to the facilities. Our sample intentionally included stakeholders from multiple levels of the health system to minimize elite bias, ensuring that the perspectives of senior health managers were balanced with those of frontline users and mid-level implementers. Below is a table summary of the participants in this study.

Table 2: Study participants

Category	Roles	Count (N)
Senior managers and stakeholders	National, provincial and district health managers	7
	Parastatal staff	2
	NGO managers and staff	4
	Academics	2
	Private sector managers	2
Implementers	Originators	2
	IT Technician	1
	Data capturers	3
End Users	Facility managers	3
	Administrative officer	1
	Nurses and midwives	9
	Admin clerks	2
Total		**38**

Data collection and management

Data collection took place between November 2021 and June 2022, which was after the E-tick project had stalled. Thus, participants, particularly implementers and end users, reflected retrospectively on the system's development, piloting, and discontinuation. Due to COVID-19 health restrictions at the time, some of the interviews with senior health managers and the implementation team were conducted virtually using video conferencing software. Interviews with end users were conducted in person in health care facilities during work hours and were conducted primarily in English, which is the standard working language in the facilities. However, participants were free to use local language terms or expressions, which were translated during transcription to preserve meaning.

Different semi-structured interview guides were used for the three categories of participants. For the managers, we inquired about the broader digital health policy landscape, existing health information systems, government readiness and feasibility for EHR implementation EHRs and the necessary next steps to advance for EHR adoption in South Africa. For the implementation team and end users, the interview guides covered topics on the purpose and origins of the E-tick, its piloting rollout, experiences with implementation and daily use, training and support, perceived benefits and challenges, and overall recommendations for improvement. Interviews varied in length ranging between 10 and 64 minutes. Shorter interviews (under 20 minutes) were mostly with busy frontline staff including clerks and clinicians during clinic hours, who provided concise but relevant insights into system use. Longer interviews were with senior health managers with authority over policy alignment, resource allocation, and procurement processes, and implementers who facilitated implementation in the 3 health facilities. Despite these differences, data saturation was reached across stakeholder groups, as no new themes emerged in later interviews. All interviews were audio recorded, and recordings were stored in a password protected computer to ensure privacy. Audio recordings were transcribed using transcription software and checked for accuracy, and transcripts were anonymized by removing participant identifying information.

Data analysis

The first author led the coding, followed by regular debriefing meetings with co-authors, who are also academic supervisors to review coding and theme development, which strengthened reliability. In this case, co-authors read all the transcripts and discrepancies were discussed until consensus was reached. The interview transcripts were coded using NVivo software. Through this process, emergent issues were identified and used to develop the themes, following a 6-step thematic analysis process (163). An inductive approach guided the thematic analysis, with broad topics derived from the interview guide, leading to the 4 stages of implementation reported in this study (Purpose and origins, Initial development, Piloting and expansion and Halt).

The accounts from the two originators formed the foundation, providing the background story and backbone of the implementation narrative, whose detailed recollections provided a chronological anchor for mapping implementation processes. These accounts were not taken at face value, but were supplemented by other participants accounts, which were used to triangulate and integrate the information into a cohesive story. After coding, the CFIR was applied to the analysis, linking the framework's 5 domains to the implementation process as reported in the study's findings (131). The CFIR framework was used to guide our analysis and reporting of our findings. In this case, CFIR constructs were operationalized as sensitizing concepts to guide coding with data excerpts being coded against relevant constructs, while leaving space for inductive subthemes to emerge. Thus, analysis combined deductive coding (using CFIR constructs) with inductive coding to capture novel themes. Multiple coders reviewed transcripts, with regular team discussions to minimize confirmation bias.

Table 3: Implementation stages and applied CFIR domains

Stages of implementation	Description	Applied CFIR domains
Origins and purpose of the system	Conception of E-tick by system originators; designed to digitize the existing tick register and reduce errors.	• Innovation • Individuals • Inner setting • Outer setting

Initial development	Early technical build and adaptation of the system, involving stakeholder input and limited resource mobilization.	• Individuals • Inner setting • Outer setting • Implementation process
Piloting	Deployment of E-tick system in three health facilities.	• Individuals • Inner setting • Implementation process
Halt	Expansion beyond pilot sites stalled due to barriers to scale up and institutionalization.	• Inner setting • Outer setting

Ethical approval

Ethics approval for this study was granted by the University of the Witwatersrand Medical Human Research Ethics Committee (M210213). Additional permissions were obtained from the Ekurhuleni district research committee and the Gauteng Provincial Department of Health (GP_202106_035).

Findings

This section presents the findings, which are ordered according to the domains of the Consolidated Framework for Implementation Research (CFIR): innovation, inner setting, individual characteristics, implementation process, and outer setting. This structure allows us to highlight how factors at multiple levels and stages of implementation shaped the processes, outcomes and ultimately the stalling of the E-tick system. To illustrate the distribution of themes across the framework, Table 4 provides a summary of implementation stages, CFIR domains and applicable constructs, thematic findings and illustrative quotes.

Origins and purpose of the e-tick (Innovation and individuals domain)

Identifying the problem

The development and implementation of the E-tick was initiated and led by a senior district manager and supported by a senior technician who was employed by the funder, labelled as Originators 1 and 2. The senior manager explained the rationale behind the project: "*Annually, the National Department of Health audits our data for accuracy, and we've always had poor audit reports. The biggest problem was the quality of the data. That's why we started the E-tick, to improve the data quality*." **(Originator 1).** The source of poor data quality was traced back to the tick register: "*The data was very poorly filled into the tick register, the services provided not counted properly*." **(Originator 1).** This was the stage where most errors occurred: "*The data issues started in the consultation room, and then the counting and the transferring of the data into the DHIS accounted for about eighty percent of the mistakes*." **(Originator 1)**. Some clinicians echoed these remarks as one shares: "*The purpose was to reduce workload and be able to say, reduce patients waiting time by doing away with pen and paper and to be able to keep our records digitally, which makes it easier to keep them*." **(Nurse 12 – AR).**

The second originator further describes how decision makers often overlook the importance of the effective data collection processes: "*The problem in South Africa is that the people who decide where the funding goes don't take data management records management seriously. They want this wealth of data so they put in these big paper registers, but they don't look at the process it takes to get that data*." **(Originator 2)**. This includes having too many registers: "*We had twenty-seven different registers, like the antenatal register for a mother and child, and a chronic disease register for HIV. The problem was that while completing all the registers, users were creating their own registers because some information was missing*." **(Originator 1).** Nurses similarly described the burden, with one stating: *"So with the E-tick it was one less writing system… our patients were registered, all the follow up visits are registered, and… it gave a clear history of the patient."* **(Nurse 13 – MM).**

Finding the solution

Against this backdrop, the idea of the E-tick began with an invitation to a staff development project to discuss potential solutions to data quality problems: "*We received an invitation*

because we already recognized a problem with data quality in our tick registers. They proposed several ways to enhance the system, involving different levels of information. While some suggestions were overly complex and resembled an Electronic Health System" **(Originator 1).** Eventually, the originators decided to make use of an excel based electronic tick register (E-tick) system: "*The organization that developed the District Health Information System …had an Electronic Tick Register and we thought we can use that to improve the data quality. But the system was just an excel sheet*." **(Originator 1).** Thus, the originators built on the excel based system: "*We decided to improve the front end, the user interface for the clients. That's how we developed the E-tick. It was basically to collect the data electronically and to be able to feed it directly into the DHIS, in a way that is easy for the nurses in the consultation rooms*." **(Originator 1)**. End users confirmed that the system was simpler and helpful. One nurse explained: *"It was user friendly. If only we would use E-tick only… we will definitely be perfect."* **(Nurse 10 – AR)**. Another shared: *"And it was also user friendly. It wasn't like I'm talking from somebody that's not very computer literate, basically… it made it very easy, accessible."* **(Nurse 13 – MM)**.

Initial development of E-tick system (Inner setting and individual domains)

Stakeholder engagement

The first originator approached a non-profit organization for funding to get the project off the ground: "*After our experience, we approached organization X for financial assistance and share our ideas with them, as [they were already] our long-term funding partner deeply involved in data collection*" **(Originator 1).** After the funders agreed, this was followed by meetings with software developers for planning: "*Once the funders agreed, we met with [software] developers to explore system development possibilities, discussed utilizing the HPRS as our registration system."* **(Originator 1)**. It was at this point that the second originator, who worked for the funding organization became involved. Together, the two originators represented two groups of stakeholders, one with the department of health and all staff at recipient facilities, and the other being with the funding organization and developers: "*[Originator 1] was very good on the clinician side and I was very good on the software side. I had been working with my team [funders] for many years before we started the E-tick, and I developed many systems with them*."

(Originator 2). As a reiterative process, the originators worked closely going between clinicians and developers: "*In a normal software development cycle, you scope your business requirements, hand it over to the team, and they will go develop what they think you want and then return to show it to you. We took a different approach. We were involved in the development, sitting with them every step of the way instead of waiting for weeks for changes. This worked extremely well."* **(Originator 2)**. Several clinicians further confirmed this engagement, with one manager explaining: *"Okay, we were called to a district to the meeting, and this was pitched, the intention was discussed with us...So the facilities that were going to be pilots were selected."* **(Assistant Director 17 – RK)**.

The originators then selected the facilities for piloting involving managers in the process: "*we used random selection and cluster sampling, through a session with all operational clinic managers, who actively participated in this process*." **(Originator 1)**. A manager from one of the facilities described their involvement: *"Okay, we were called to a district meeting, and this was pitched, the intention was discussed with us...So the facilities that were going to be pilots were selected*." **(Assistant Director 17 – RK)**.

System development

After selecting the facilities for piloting, the system was taken to recipient facilities as one clinician recalls: *"They called us for like a mini meeting to inform us about E-tick and told us that we were one of the only clinics currently using it, and they were piloting to see if it's going to work."* **(Nurse 10 – AR)**. In the meetings, one of the goals was to find ways to streamline the patient consultation: "*We focused on what made it easy for clinicians to help the patients without them waiting too long. But a bonus that came out of the system is that the system was also able to retrieve a patient's entire history.*" **(Originator 2)**. The clinicians provided feedback: "*The clinicians had great ideas. The first time we had the screens ready, we took it back to the clinicians and asked them if this is what they wanted, they approved it and gave suggestions for changes, which we did*." **(Originator 2)**.

Several engagements were made with the provincial Department of Health to gain support and input on issues such as data storage: "*When we began the pilot, we engaged the Provincial office and kept them informed about the program. A provincial manager suggested storing the data on provincial servers instead. However, they weren't prepared to proceed at that time.*" **(Originator 1).** To ensure this was possible later, the developers ensured the system was compliant: "*We looked at the Departments of Health security and ICT standards, we worked with the Department of Health ICT team as well, and their data team.*" **(Originator 2)**. However, this did not go as planned as the data centre was not ready in time: "*The idea was to eventually transfer the system and its data to the department's data centre once it was established. However, when we developed it, there was no data centre for us to put it in, and we had complied with all the national standards for the developing systems*." **(Originator 2).**

Piloting and expansion (Inner setting and implementation process domains)

Planning and configuration

In all three chosen facilities, the originators conducted an infrastructural assessment before beginning the pilot: "*we had to check that all computers were working, and that they all had network. The developers didn't want to have a local server for each clinic because it's too complicated. So they changed the system to an online system that worked with the cloud*." **(Originator 1)**. Some of the existing infrastructure was from the Department of Health: "*We only had to get the computers for the Provincial clinics. So that already made life much easier. Because every clinic, every clinician had a computer, or most of them*." **(Originator 1)**. A technician from the health department was involved in configuring them: "*My role was to check infrastructure, to see if it's there. But they also installed some private infrastructure because of some policies with our network which would require a lot of approvals before we can run it*." **(IT Technician)**. This was further supplemented by the funding to improve the infrastructure: "*They [funders] assisted us and made sure that each room had a network cable. Sometimes there were no plugs, so they put in the plugs. They put in the routers*." **(Originator 1)**. The planning and configurations also informed decisions on devices that were to be used: "*We wanted to see what the nurses and the clinicians felt more comfortable with, the tablets or the desktops. Due to a lack of space in*

some consultation rooms, which were too small to put a big desktop, it was easier to mount a tablet onto the wall." **(Originator 2)**.

Training and learning

A comprehensive user training was provided in recipient facilities, which was tailored for specific roles: *"There were different training categories, because the roles were different like, clerks, clinicians and so on. It was [also] not just one training, it was several; this was because the facility was working on shifts, so they had to accommodate everyone. During rollout, there was another in-service training just to remind the staff.*" **(Nurse 17 – RK)**. Moreover, the training was supplemented by regular visits for support and monitoring: "*Then we had regular visits from [the originator], often enough for us to deal with whatever issues we were having on the system*." **(Nurse 2 – MM)**. The training was simple and accommodated varying levels of skills: "*Some people could not use computers, but it was made as basic as possible to include those that are not computer literate*." **(Nurse 17 – RK)**. However, some users' competency and reactions to the training were influenced by age: "*For the young ones, it was easy for them. For the old ones, it was a problem because they wanted to understand what they were ticking as they were pressing.*" **(Data capturer - 1)**. In response, the originators sought assistance from data capturers, acting as an immediate source of help: "*We had person in each clinic who would be there all day long. So for the first day or two they would sit with them [older users] when they completed it, until they became comfortable with it*." **(Originator 1)**.

Support and feedback channels

To supplement the training, the originators had different people involved to provide support to end users, including IT technicians: "*We provided desktop support, we were the first line of support. My role firstly was on all applications and IT projects running within the district*." **(IT Technician)**. While data capturers were already involved, especially in the early stages, admin people also assisted with various tasks: "*We also had three admin people, one for each clinic that assisted in the clinic to help people with the training, setting up the system and checking that the computers are all working*." **(Originator 1)**. The originators also established communication

channels to receive feedback from users: "*We had a little book for users to report issues and to add anything, and an E-tick admin person was there. I also got information from data capturers and I would also go and check on everybody and they would give me feedback. We would report back to them monthly, usually*." **(Originator 1)**.

Perceived benefits of system use

End users reported several benefits of the system, with some sharing how it improved continuity of care: *"At times you find that the client may have been seen previously but the file could not be found. But if the client's details were captured on the previous visit, you could see it in the E-tick. So it helped with continuation of care."* **(Nurse 11 – AR)**. For other users such as clerks, this reduced patient waiting times: *"It also reduced the waiting period for the patient, because the first thing that we do is to register the patient and create a folder on the E-tick system. It's easier to use than retrieving the manual files, searching the files in the cabinets. When you're using an E-tick, you just search on the system."* **(Admin Clerk 8 – AR)**. Facility managers also found operational benefits such as quicker service delivery: "*The benefits were that the patient consultation times were shortened. It was a little bit faster. That was the best advantage that I've seen from the E-tick."* **(Operations Manager 18 – RK)**. Some users shared that the system improved data quality and access to it: *"It improved the reporting of data. We had very reliable, consistent, and accurate data, at all times of the day."* **(Administrative officer 19 – RK)**. For some, the system enabled the monitoring of the clinic's performance: "*We are able to evaluate ourselves on the number of patients that we are seeing. When our stats are sent to the DHIS, they can see that we are really performing."* **(Nurse 4 – MM)**.

Perceived challenges of system use

Users reported several challenges with using the system, including the simultaneous use of the system with the manual: *"To be brutal, they [users] were against it at first. They did not understand why we're implementing extra work for them."* **(Administrative officer 19 – RK)**. For some participants, the early days before mastering the system was difficult: *"If you're not used to it yet, it takes time to get used to anything, especially if you're overloaded with a lot of*

patients." **(Nurse 14 – MM)**. In some cases, short staffing led nurses to do administrative work, as one nurse shared: *"I think it was mostly shortage of staff, sometimes I had to enter a new patient into the E-tick as a nurse, which would waste time and to delay the queue. You'd end up having to turn some patients back. So it needs us to be well staffed*." **(Nurse 12 – AR)**. In response, the originators designated roles for receptionists, clerks and data capturers as the first point of contact for patient registrations.

There were concerns about the hardware and infrastructure that were already existing in the facilities: *"The [DOH's] ICT equipment was very outdated. Some of the computers are so old and they haven't been updated."* **(Originator 1 – R)**. Some users had challenges with the network infrastructure: *"Our network system was failing us a lot. You'd be prepared to start the day and notice that you have no network*." **(Nurse 12 – AR)**. In response to this challenge, a back capture function was introduced, which allowed information to be captured into the system at a later stage. In one site, hardware was frequently stolen: *"First disadvantage was theft. I'd say more than more than 70% of the tablets disappeared. All the rooms that had extension cords, but in less than two weeks, all the rooms had no extension cords. They also stole the chargers."* **(Administrative officer 19 – RK)**. In one clinic, the piloting coincided with ongoing protests by nurses: *"When we were trying to start the system, the nurses and others would be outside complaining about the conditions in the clinic [a protest organised by unions]. Most of the nurses were not working. There were other issues in the clinic. I think they saw the E-tick as another thing that was worth protesting about, because it increased their workload."* **(Originator 1 – R)**.

Halt (Outer setting domain)

Changing developers

Despite its relative success in implementation, several complications affected the continued use and development of the system. One of the complications came when there was a change in the software developing company: "*Originally [funders] were working with [a software developing company], who were helping with developing district programs. They were taken over by [another company] so the people that worked on our system were taken off the project, and a new team*

took over the development." **(Originator 1 – R)**. This affected the further developments: "*We needed to update the system to make sure it's fine. Then it got stuck in that development phase because of the new developers that we have.*" **(Originator 1 – R)**. Some of the previous work was undone by the new developers: "*There were a lot of upgrades to the system, such as integration with the DHIS. But they removed some of the functionalities that were working well in the process. We were never happy with the final products that we got from them."* **(Originator 1 – R)**.

Funding cuts

The change of developers brought higher costs: "*They [funders] agreed to pay for the additional development, but the new developers came with a lot of red tape and were quite expensive. The funding got cut and they could only give us a small amount to continue with the development*." **(Originator 1 – R)**. Moreover, the funders were eventually withdrawn from operating in the health district: "*They [funders] moved out of the district, because their funding got cancelled completely. So what's happening with their funding will affect our funding*." **(Originator 1 – R)**. This had an impact on keeping the system operational: "*So because it's not open source, it was built on the Microsoft platform and the cost to keep it running is high. It's also web based so no offline capability, and we need constantly running servers*." **(Originator 2 – T)**. Thus, the system needed new funders: "*We're looking for partners to fund the service, license costs and the implementation in facilities. To date, we haven't found anyone, so it's been put to sleep*." **(Originator 2 – T)**.

Provincial and district support

The originators had buy-in from district officials, who were in support of the system: "*I had meetings with my chief director, and my director, and they are still very keen. The clinics are still very keen… So the buy-in is there, even after two to three years, but the funding is not there*." **(Originator 1 – R)**. However, the provincial health office's priority was to develop a new system, as the department technician explained: "*Currently the department is rolling out an HIS platform where all other applications will be layered under and integrated into*." **(IT Technician)**. He further explained how locally developed systems were not as prioritized: "*There were some contrasting*

and opposing views. The system was started from scratch but the department in most cases doesn't want that. They want to go on the market and buy something on the shelf. I don't think approvals were going to be granted." **(IT Technician)**. The participant further mentions how the IT staff are often not seen as essential to the role of delivering care: "*Sometimes different services compete for resources. They will say it's essential when it's a clinic, a doctor or medication, and then we [IT personnel] come last.*" **(IT Technician)**. The originators also expressed their frustration with navigating such terrain: "*So this is where we are stuck now. I think what is important to me is how difficult it is to roll out a system within the Department of Health, in the politics, the corruption and the agendas of people. It makes the story very complicated because we developed it the bottom up, seeing the need, with the buy-in from the district, and from all the role players*." **(Originator 1 – R)**.

Broader context (Outer setting domain)

Senior managers and external stakeholders shared insights into the Department of Health's challenges in implementing EHRs in South Africa. One manager notes how implementation requires a joint and collaborative effort of various stakeholders: "*I think it's a complex sociotechnical project to do which requires many different role players and expertise and costs, which needs high level support from the National Department of Health which has been lacking*". **(NPO manager)**.

The Provincial Health Departments hold most of the decision-making power in digital health spending: *"The national office can come up with guidelines and frameworks and ask for reports but the actual spending on health information systems is done at provincial."* **(NPO manager)**. In this case the Provincial Health Department had decided to prioritize an off the shelf system: "*There is a provincial initiative and anything new that comes in has to talk to this one, there should be interoperability…I saw it [E-tick], it works. I tried to support it but we didn't get provincial support from the CIO".* **(Provincial manager)**. However, NGOs have been supporting and implementing local efforts to build systems (such as E-tick) in healthcare facilities: "*NGOs are doing better than the districts and the provincial health in terms of implementing efficient*

systems. Most efficient systems are systems that have been introduced by NGO's instead of our provincial department". **(Provincial IT technician)**.

Some participants raised a concern over political appointments in key decision-making positions: **"***I don't believe that we have the right people in government with the right industry experience…They are just given the title and suddenly, they now have to make decisions. I think it's very wrong and it sets them up for failure*." **(NGO Technician)**. A health department technician added: **"***Most of our activities are driven by politicians while our head of department has his own strategies. We get our mandate from politicians.*" **(DoH Technician)**. As a result, some decisions are made with bias: "*There are bureaucratic officials in Department of Health national, provincial and local. If they do not like you and your project, they will say you have to go through SETA [a parastatal] which is extraordinarily slow, not particularly technically competent, and staggeringly expensive.*" **(NPO manager)**. Moreover, one academic shared their experience with the department of health's reluctance: **"***I think there's not sufficient trust on the part of Government certainly in my experience. They are not coming to partner with us. In fact, they're pushing us away. We only get close when we work with NGO's and so on. The Government definitely keeps us at arms-length."* **(Health Academic)**.

Corruption and inefficiencies have also created barriers, with the tender system being one of the issues: "*It [corruption] is part of the tender system in South Africa, unfortunately the tender system is open to abuse.*" **(Provincial health manager - IT)**. Moreover, past corruption scandals have tainted the reputation of the Department of Health: "*The perception is that you can't trust the National Department any longer to do anything. No one is going to give the National Department a big pot of money to run a tender until it can show that it's got systems and people in place who can do it without squandering the money.*" **(National health manager)**. This mistrust has also led to reluctance to work within the department: "*Now people are reluctant to work for the department for several reasons. They fear being embroiled in controversy and putting their personal integrity at stake.*" **(National health manager)**.

Discussion

The E-tick system, the innovation, was developed to address the issue of poor data quality stemming from errors in data collection which were common with the use of paper-based registers. The implementation process involved an iterative co-designing process with input from all involved individuals including end users and stakeholders to ensure user's needs were met and to streamline the data entry process while supporting scalability and integration with other systems. Despite the system's successful piloting and user adoption in the inner setting, the outer setting posed challenges in funding, change of developers and lack of support from the provincial health government, leading to the implementation stalling. Using the CFIR, we explored the interaction of different elements, actors and stakeholders and how they facilitated or impeded implementation. As such, we organize our discussion around CFIR domains, highlighting both facilitators and barriers.

Innovation

Poor data quality is a problem that commonly affects routine monitoring of health outcomes (221). The E-tick system had a clear relative advantage over paper-based registers to improve data quality and reporting. Errors that frequently compromised data quality and routine reporting were minimized, and users perceived the system as more streamlined than paper-based manual registers. At a national scale, this aligns with South Africa's policies that promote the digitization of record keeping and the establishment of a national electronic health record (142,222), a crucial component for strategic purchasing and health monitoring. The E-tick's co-design process enhanced usability and fostered buy-in, which is critical in adoption (223), yet innovation alone was insufficient to ensure sustainability.

Individuals

At the level of individuals, the originators showed strong commitment by providing vision, technical expertise and persistence in driving the implementation of the E-tick system. Leadership practices are known to impact staff motivation especially when they take a participatory approach (224,225). Their leadership was instrumental in mobilizing resources, persuading managers and funders to support the system's adoption, acting as champions along

with data capturers. Research shows how champions are crucial in promoting technology adoption through building enthusiasm and providing peer support (226). End users also improved confidence in using the system as a result, especially after undergoing training, which sustained motivation during the pilot. However, while the successful adoption of the E-tick was due to the contribution of many actors including external stakeholders, individuals in the inner setting were more affected by decisions in the outer setting. This reflects a broader challenge in digital health implementation in South Africa, that for locally developed systems to succeed, appropriate actors must be in place to provide leadership, vision, and sustained support, within an enabling environment that fosters continuity and long-term success (156,224).

Inner setting

Within the inner setting, several facilitators supported early implementation, such as the co-design process and extensive user training. The originators successfully engaged a wide range of stakeholders including senior managers and funders, which was pivotal in overcoming initial financial and political barriers. Involving end users was also crucial in enhancing the system's usability and promoting buy-in, an important aspect when ensuring effective user adoption (227,228). Moreover, users' recognition of the system's value in improving data quality reinforced their motivation to adopt the system. Studies in other low to middle income countries show that organizational commitment is a critical success factor to sustain user motivation during piloting phases (229). However, the sustained use of the E-tick required stable infrastructure, which often posed challenges for many users in the form of interrupted internet connectivity and power cuts. This mirrors challenges reported in other LMICs, where infrastructural fragility such as poor internet connectivity and unstable power supply are common challenges to EHR adoption (230). Moreover, without dedicated budgets to overcome these challenges such as the use of mobile internet devices and backup power solutions, this creates uncertainty about sustained use.

Implementation process

The implementation process revealed a mix of strengths and gaps, which were closely linked to the role of individuals and the inner setting. A key strength was the iterative co-design approach,

which ensured that the system was not only technically functional but also responsive to user needs and compatible with existing workflows. Participatory design and user engagement are widely recognized in implementation science as best practice, as they enhances user ownership, adaptability, and long-term adoption, especially as most implementation efforts fail due to user resistance (231,232). Thus, involving both clinicians and managers at early stages of the implementation process helped to align the E-tick system with user realities, reducing resistance to change. However, this process was undermined by a lack of a long-term financing mechanism and failed provincial support, despite the demonstrated proof of concept at pilot phase. Therefore, while the implementation process was well executed, the system lacked the institutional anchoring and support for long term use, a critical success factor of digital health efforts (23).

Outer setting

We found that the most significant challenges were encountered in the outer setting, particularly the withdrawal of financial support, change of developers and lack of support from the provincial health government due to its lack of capacity. Studies show that one of the main challenges to the initiation of digital health initiatives including EHRs in South Africa has been the poor governance and lack of political will (233,234). For instance, the appointment of people without the required skills and competence has led to a chain of events that affect institutions such as the Gauteng provincial health department (235). As a result, corruption has eroded the public's trust in the government. These issues are not isolated but rather reflective of the entrenched political economy dynamics that routinely affect digital health innovations in South Africa. Political appointments, who are put in place because they are easily manipulated, often make decisions driven by political interests rather than professional judgement, leading to the political control of government institutions and their spending (236). As such, patronage networks often produce politically aligned rather than skilled appointments. This leaves room for corruption, irregular spending, fraud and poor oversight to mitigate them, with procurement processes being vulnerable to perverse incentives with contracts awarded to less qualified but politically connected vendors. Although efforts have been made to uncover large scale corruption in South Africa, the necessary mechanisms have not yet been put in place to deal with the challenges

(237,238). Perverse incentives undermine sustainability as officials face pressure to launch new initiatives instead of sustaining existing ones to ensure full expenditure of budgets.

The administrative fragmentation can be seen as a product of South Africa's federal system means provinces can develop their own health information systems (bottom-up) or acquire them through separate procurement processes (top-down) (202). In this case, despite the provincial government's preference for a top-down approach by opting for an off-the-shelf system over the E-tick, they were unable to implement the former. High income countries such as the UK, the USA and Australia have taken top-down, bottom up and middle out approaches respectively with varying outcomes (239). Bottom-up approaches often build on existing systems, such as the E-tick, using interoperability standards to integrate them across facilities. In contrast, top-down approaches replace local systems with a centralized EHR, but this can be too complex, limiting flexibility and local adaptability as in the case of the UK (240). Therefore, our analysis shows that a single centralized model is not necessarily more effective as lessons from these experiences, including Australia, suggest that a middle out approach is more effective as this blends both by offering central guidance while allowing for local systems to gradually align with national plans (241).

Implementing EHRs requires significant investment, vision, robust management systems and strong oversight to sustain them, making effective leadership essential for success. Strong leadership plays an important role in guiding decision making, mobilizing the right expertise and establishing mechanisms to prevent corruption which increases the likelihood of successful implementation, particularly for largescale EHRs (242). Middle income countries like South Africa and China have the capacity to finance and support EHR adoption, but such efforts can be undermined by corruption and poor governance (234,243). In some cases, poor leadership and governance stand as significant barriers to achieving universal health coverage and strengthening health systems (244).

Implications for policy and practice

Our findings highlight several implications for policy and practice. One of them is the strengthening of accountability in health systems through transparent procurement systems and

independent oversight to neutralize the effects of corruption and political patronage. In such cases, procurement frameworks could include pilot to scale pathways, where bottom-up innovations such as the E-tick could be formally assessed against national priorities and considered for integration with provincial and national systems. These steps could create a more enabling environment for similar innovations to scale sustainably. Moreover, while the E-tick system was locally hosted, it also incorporated cloud functionality, aligning with the cloud based EHR architectures promoted in both the national digital health strategy and the national data and cloud policy of South Africa (142,245). Such policies can be leveraged to mitigate barriers such as reliance on facility servers or hardware failures, challenges already observed with the E-tick which hold important lessons for similar middle income country contexts.

Our findings also carry implications for digital health equity, a concept that examines how structural inequities shape the successes and challenges of digital health interventions (246). In South Africa's dual health system, where private-sector facilities often have better infrastructure and resources than the public sector, grassroots innovations like E-tick are left to face compounded challenges especially when implemented in low resource contexts (247). The stalled scale-up reflects not only outer system or structural barriers by the government but also the broader inequities in digital infrastructure, institutional support, and resourcing across the country's health system (248).

Limitations

Our study incorporates perspectives from a diverse range of stakeholders including higher level managers, decision makers, academics and end users from recipient facilities. This diversity helped in capturing nuanced perspectives from different positions within the system and to close information gaps through triangulation. A limitation of our study is that data collection from the implementation team, especially clinicians, occurred over a year after the system had halted. As a result, some participants struggled to accurately recall past events, while others had moved to different jobs by the time of data collection. As a result, formal member checking with participants was not possible due to staff turnover and the discontinuation of the E-tick project. However, we validated emerging findings through iterative review with co-authors who included

experts in South African health systems and originators who led the implementation from the beginning and had contextual expertise.

Conclusion

In conclusion, the E-tick system is a valuable innovation which was developed ground up with user input. While the system showed promise, its long-term sustainability was undermined by external factors such as funding cuts and poor support, political appointments and corruption, which led to the unwillingness of provincial officials to support local initiatives such as the E-tick. Such bureaucratic inefficiencies also affected the capacity to move forward with another system. This study demonstrates that without alignment to broader factors such as governance, corruption and skilled leadership, innovative systems such as the E-tick will struggle to be implemented.

Table 4: Summary of each stage of implementation with the corresponding CFIR constructs

Implementation stage	CFIR domains and constructs (applicable)	Thematic findings	Illustrative quotes
Origins and Purpose	**1.1 Innovation** a. Relative advantage b. Design quality and packaging c. Adaptability	The E-Tick was developed to address poor data quality from paper-based tick registers, offering a clear improvement in accuracy and efficiency. Its adaptable design allowed integration with DHIS, and it improved upon a basic Excel system.	*"They were trying to lessen discrepancies of data. So primarily, I saw e-tick as that main role. But what was communicated was that it would help us manage a patient and go paperless."* **(Nurse 19 – RK).** *"That's how we developed the E-tick. It was basically to collect the data electronically and to be able to feed it directly into the DHIS, in a way that is easy for the nurses in the consultation rooms."* **(Originator 1).**
	1.2 Individuals a. Knowledge and beliefs about intervention b. Self-efficacy	Originators believed in the intervention's value and understood how it could address system inefficiencies. They also felt confident in their ability to deliver it due to prior experience with data systems.	"*[Originator 1] approached us with this idea that to remove the paper registers from facilities to capture the data electronically using mobile devices. So we had a big interest in this, obviously, because it will improve our data*" **(Originator 2).** *"It improved the reporting of data. We had very reliable, consistent, and accurate data, at all times of the day."* **(Admin officer 19 – RK).**
	1.3 Inner setting a. Tension for change	There was shared recognition of the need to improve data quality, which created urgency among district-level leaders and implementers.	*"We've always had poor audit reports. The biggest problem was the quality of the data. That's why we started the e-tick, to improve the data quality."* **(Originator 1).** "*We wanted to lessen discrepancies of data, in the sense that when in the consultation rooms, we've got this tick register book, that needs to be calculated by the clinician, the clinician ticks and then calculate at the end, sometimes with errors*". **(Nurse 17 – RK).**
	1.4 Outer setting a. Patient needs and resources b. External policies and incentives	Persistent audit failures and national reporting needs created external pressures to improve data systems. However, national policy did not yet support bottom-up digital solutions like E-tick.	*"The problem in South Africa is that the people who decide where the funding goes don't take data management records management seriously. They want this wealth of data so they put in these big paper registers, but they don't look at the process it takes to get that data."* **(Originator 2).**
Initial Development	**2.1 Individuals** a. Individual identification with the organization	The two originators took ownership of the system, identifying strongly with the project's goals and acting as	*"[Originator 1] was very good on the clinician side and I was very good on the software side. I had been working with my team [funders] for many years before we started*

	b. Self-efficacy	champions to drive development and gain buy-in.	*the E-tick, and I developed many systems with them."* **(Originator 2).**
	2.2 Inner setting a. Network and communication b. Compatibility c. Available resources	Effective collaboration between clinicians, developers, and funders enabled iterative co-design. The system was built to align with existing clinic workflows and facility infrastructure, although resource gaps were bridged by external funders.	*"My role was to check infrastructure, to see if it's there. But they also installed some private infrastructure because of some policies with our network which would require a lot of approvals before we can run it."* **(IT Technician).** "*One person came to train us and it was a teaching. So whoever was in the room was taught, then we continued practicing on our own and helping and assisting each other when we struggle*" **(Nurse 3 – MM)**
	2.3 Outer setting a. Cosmopolitanism	Relationships with external partners (NGOs, funders, developers) were central to initial system development and support.	"*We approached [funders] for assistance and presented our idea to them…as they were our long term funding partner and they were also very involved in data collection…so at that point they agreed then we had quite a lot of meetings*" **(Originator 1).** "*In a normal software development cycle, you scope your business requirements, hand it over to the team, and they will go develop what they think you want and then return to show it to you. We took a different approach. We were involved in the development, sitting with them [developers] every step of the way instead of waiting for weeks for changes. This worked extremely well*." **(Originator 2).**
	2.4 Implementation process a. Planning b. Engaging	The system was introduced through structured and consultative meetings and workshops with facility managers and end users. Clear planning with stakeholder involvement promoted ownership.	*"We were called to a district meeting, and this was pitched, the intention was discussed with us...So the facilities that were going to be pilots were selected."* **(Assistant Director 17 – RK).** *"They called us for like a mini meeting to inform us about E-tick and told us that we were one of the only clinics currently using it, and they were piloting to see if it's going to work."* **(Nurse 10 – AR).** *"They called us for like a mini meeting to inform us about E-tick and told us that we were one of the only clinics currently using it, and they were piloting to see if it's going to work."* **(Nurse 10 – AR).**
Piloting and Expansion	**3.1 Individuals** a. Self-efficacy b. Knowledge and beliefs	Staff competency varied, especially across age groups as younger staff adapted quickly while older staff needed more support. Nonetheless, most users believed in the system's usefulness after onboarding.	*"For the young ones, it was easy for them. For the old ones, it was a problem because they wanted to understand what they were ticking as they were pressing."* **(Data capturer - 1).** *"At times you find that the client may have been seen previously but the file could not be found. But if the client's details were captured on the previous visit, you*

			could see it in the e-tick. So it helped with continuation of care." **(Nurse 11 – AR).** *"And it was also user friendly. It wasn't like I'm talking from somebody that's not very computer literate, basically… it made it very easy, accessible."* **(Nurse 13 – MM).**
	3.2 Inner setting a. Readiness for implementation b. Structural characteristics	Facilities had computers, although some infrastructure upgrades (e.g., hardware, cabling) were needed. Clinics varied in preparedness, but funder support helped bridge gaps.	*"They [funders] assisted us and made sure that each room had a network cable. Sometimes there were no plugs, so they put in the plugs. They put in the routers."* **(Originator 1 – R).** *"Our network system was failing us a lot. You'd be prepared to start the day and notice that you have no network."* **(Nurse 12 – AR).** "*First disadvantage was theft. I'd say more than 70% of the tablets disappeared. They were secured in those stands that use the unique screws to lock them after but people took them out without even needing to remove the screws.*" **(Nurse 19 – RK).**
	3.3 Implementation process a. Executing b. Reflecting and evaluating c. Engaging	Continuous user training, feedback loops, and system adaptations occurred during this stage. System benefits (faster service, better reporting) were widely acknowledged by users.	*"There were different training categories, because the roles were different like, clerks, clinicians and so on. It was [also] not just one training, it was several; this was because the facility was working on shifts, so they had to accommodate everyone. During rollout, there was another in-service training just to remind the staff."* **(Nurse 17 – RK).** *"It also reduced the waiting period for the patient, because the first thing that we do is to register the patient and create a folder on the E-tick system. It's easier to use than retrieving the manual files."* **(Admin Clerk 8 – AR).** *"And it was also user friendly. It wasn't like I'm talking from somebody that's not very computer literate, basically… it made it very easy, accessible."* **(Nurse 13 – MM).**
Halt (Stall)	**4.1 Individuals** a. Champion b. Other personal attributes	The originators remained committed but were unable to maintain momentum due to systemic barriers beyond their control.	"*The Provincial office decided to develop a whole new system, ignoring all the existing systems that were there. When I asked them, they said, obviously they want to keep using the existing systems and we need to have a bilateral agreements on how to keep the e-tick information into the system.*" **(Originator 1 – R).** *"I think there's not sufficient trust on the part of Government certainly in my experience. They are not coming to partner with us. In fact, they're pushing us*

			away. We only get close when we work with NGO's and so on. The Government definitely keeps us at arms-length." **(Health Academic).**
	4.2 Inner setting a. Available resources b. Implementation climate	Funding cuts and change of developers led to diminished support for sustained adoption. Facility staff were frustrated, and momentum was lost despite initial enthusiasm.	"Eventually the funders moved out of [the district] and basically all the funding was cut finally, and they've given the system over to us [originators] to manage. So they are not part of the funding anymore but would only fund the basics like holding the data up to when we get a new funder." **(Originator 1).**
	4.3 Outer setting a. External policy and incentives b. Peer pressure c. Leadership engagement	Provincial authorities did not support E-tick due to conflicting strategic plans and preference for proprietary systems. Moreover, political interference, lack of intersectoral collaboration, corruption in the tender system, and distrust in government procurement severely undermined bottom-up innovations.	*"There is a provincial initiative and anything new that comes in has to talk to this one, there should be interoperability…I saw it [e-tick], it works. I tried to support it but we didn't get provincial support from the CIO".* **(Provincial manager).** *"There were some contrasting and opposing views. The system was started from scratch but the department in most cases doesn't want that. They want to go on the market and buy something on the shelf. I don't think approvals were going to be granted."* **(IT Technician).** *"I think it's a complex sociotechnical project to do which requires many different role players and expertise and costs, which needs high level support from the National Department of Health which has been lacking".* **(NPO manager).** *"I don't believe that we have the right people in government with the right industry experience…They are just given the title and suddenly, they now have to make decisions. I think it's very wrong and it sets them up for failure."* **(NGO Technician).**

CHAPTER 7: What engagement strategies are useful in facilitating the implementation of electronic health records in health care settings? A rapid review of qualitative evidence synthesis using the normalization process theory.

Published paper title:

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Statement of Co-author Contributions

Lead author (Candidate - Campion Zharima): The candidate led the conceptualization and study design, conducted primary data collection, carried out data analysis, and wrote the first draft and subsequent revisions of the manuscript.

Co-authors (Supervisors): The supervisors primarily provided guidance on framing the research questions, offered critical feedback on analysis and interpretation, and reviewed and approved manuscript drafts. Their involvement was from the conceptualisation stage up to the publishing of the paper.

Co-authors (Colleagues): Colleagues contributed to the screening of articles and assisted in data extraction and preliminary analysis.

Abstract

Objective: The study aimed to identify and describe the engagement strategies used in implementing electronic health records in health care settings and to ascertain why they were successful or not.

Methods: In this rapid review, we searched PubMed and CINAHL for qualitative and mixed methods primary studies published from 2010 to 2023 (June). We identified 41 studies that explored the implementation of EHRs, involving clinicians as participants. For quality appraisal, we employed the Standards for Reporting Qualitative Research (SRQR) tool. For analysis, a qualitative comparative analysis, using the Normalization Process Theory was conducted. This was followed by a narrative synthesis to compile and analyze key findings.

Results: About 56% (n=23) of the studies were conducted in hospitals, while the remaining were done in mental health, maternity, and ambulatory care settings. Participants included a range of clinicians such as nurses, physicians, doctors, dentists, pediatricians and other specialists. Evidence shows that prior to implementation, effective communication of the vision of EHRs, early user involvement in decision-making are useful engagement strategies in preparing users for implementation. Tailored training and on-demand technical support for users sustain system usage during the roll out. Lastly, ongoing engagement with users is essential for continuous user support and system improvements.

Conclusion: User engagement improves the chances of successful implementation, particularly if engagement strategies are effective for the specific stages of implementation. The success of these strategies is more evident when they ensure NPT tenets, which include user coherence, cognitive participation, collective action and reflective monitoring.

Keywords: User engagement, electronic health records, implementation, qualitative, healthcare setting, normalization process theory, review

Introduction

Electronic Health Records (EHRs) are a patient-centric information resource for clinicians and a longitudinal record of patient information and service provision for managers (249,250). They enable clinicians to perform their duties more efficiently by improving diagnostic precision, coordination and delivery of care and clinical decision making (250–252), thereby acting as a tool for recording, handling and sharing health data. The World Health Organization (WHO) urges governments to invest in digital health solutions like EHRs, especially for low and middle income countries working towards universal health coverage (169,234).

Despite the potential for EHRs to improve the delivery of health care, implementing EHRs is often difficult and can result in negative and unanticipated disruptions to clinician workflow (55). Organization leaders exert greater control over the implementation processes, while end users often have a more intimate understanding of the care delivery process (253). Where leaders fail to meaningfully engage end users, it leads to implementation failures (228).Health care settings are dynamic networks of interactions between people and processes (119). Introducing a new sub-system such as an EHR in health care settings has implications for end users and their workflow patterns (254). As a result, implementing EHRs requires a synergistic approach involving a top-down and bottom-up direction, with the latter gained through user engagement.

User engagement can include activities to consult, involve or partner with end users of EHRs throughout the implementation process, thereby presenting opportunities to identify and solve implementation challenges in real time (228,255,256). Activities could be involving users in decision making processes, partnering with them to co-create solutions, conducting focus groups or feedback sessions to understand user needs. Engagement ensures that implementation is a collaborative process, ensuring that end users' needs and workflows are accommodated, to promote ownership and acceptance of the new system (254).

Evidence on the implementation of EHRs

Evidence on the implementation of e-health systems, including EHRs, has been synthesised in two notable reviews, both of which utilized theoretical frameworks: the Consolidation

Framework for Implementation Research (CFIR) (55) and the Normalization Process Theory (NPT) (54). The CFIR focuses on the contextual determinants of implementation outcomes while the NPT explains the behaviours and thoughts underlying technology adoption by users (135). Although these two reviews are not specific to EHRs, they elaborate on the importance of user engagement and deploy useful theoretical frameworks.

The Ross review, using the CFIR shows the importance of stakeholder engagement during the development, planning and execution of implementation processes (55). The Mair review, using the NPT concluded that user engagement is central to successful implementation of new technology, but there are limited efforts aimed at actively involving health professionals during implementation (54). Although both reviews underscore the importance of user engagement, they do not explore engagement strategies and factors that promote or inhibit user engagement. While the CFIR carries a wider focus on broader factors of implementation, the NPT carries more depth in explaining the mechanisms of user engagement (55).

There are several reviews on EHR implementation which report on the factors affecting implementation such as the influence of organizational, human and technological factors (257–259). While these reviews emphasize implementation strategies including user involvement, they fall short of synthesizing the strategies necessary for effective user engagement. In this rapid review, we identify and describe the engagement strategies used in implementing electronic health records in health care settings, whether they were perceived as successful and, using normalization process theory, to ascertain the reasons why they were successful or not.

Normalization Process Theory (NPT)

We use normalization process theory (NPT) for this review, a framework developed to fill the gap in addressing the work of individuals and groups during implementation (54,126). The NPT explores the factors influencing the routine embedding of complex interventions into everyday practice (260). Thus, the theory holds practical value by offering a means to assess implementation from a user's perspective (261,262).

The theory incorporates four constructs, used in this review to evaluate engagement strategies: coherence (or sense-making), cognitive participation, collective action and reflexive monitoring

(260,263). These constructs interact and influence one another. Table 1 below shows the definitions of the NPT's constructs and the operational definitions used for this review.

Table 1. NPT constructs as defined by Finch et al (263)**.**

NPT Construct	Conceptual definition by Finch et al.	Operational definition (for engagement strategies)
Coherence or Sense making	The process of sense-making and understanding that individuals and organizations have to go through in order to promote or inhibit the routine embedding of a practice to its users. These processes are investments of *meaning* made by participants.	Does the strategy enable users to understand and make sense of the new system, how it differs from the old, the value of the new practice and the work that needs to be done to integrate the new system into their workflow?
Cognitive Participation	The process that individuals and organizations have to go through in order to enroll other individuals to engage with the new practice. These processes are investments of *commitment* made by participants	Does the strategy include key personnel, build user relationships for support, drive change, establish sustainability procedures, and ensure effective system functioning?
Collective Action	The work that individuals and organizations have to do to enact the new practice. These processes are investments of *effort* made by participants.	Does the strategy facilitate the operational work necessary to support a new practice, which involves how people interact with each other and with the system, making sure everyone understands their roles and responsibilities, and how resources are managed to make the new system or process work effectively?
Reflexive Monitoring	The informal and formal appraisal of a new practice once it is in use, in order to assess its advantages and disadvantages and which develops users' comprehension of the effects of a practice. These processes are investments in *appraisal* made by participants.	Does the strategy allow users to assess the new practice by looking at how it affects people and their work, and then deciding if any changes are needed based on what they find?

Methods

We conducted a qualitative evidence synthesis using a rapid review approach. Rapid reviews use an accelerated process compared to standard reviews, allowing researchers to draw insights from scientific evidence in a timely and resource efficient way (264). This rapid review's protocol was registered on the PROSPERO database: **CRD42021275000**, and is reported following the Enhancing transparency in reporting the synthesis of qualitative research (ENTREQ) statement (265). No amendments were made to the information provided at registration or in the protocol.

Search strategy

The search strategy (see appendix A) was adapted from the reviews conducted by Ross and Mair on the factors affecting the implementation of E-Health systems (54,55). For this review, the strategy was narrowed to search for studies on the implementation of EHRs only. Using the rapid review approach, we limited our search to only two electronic databases as more databases would increase the number of hits while diminishing the number of included papers. A systematic Boolean search method was employed on the 23rd of June 2023 using key operators (such as OR and AND) truncated to find relevant literature. The search utilized two categories of keywords (see appendix A), using Medical Subject Headings (MeSH) terms related to "Electronic health records" and terms related to "Implementation". The search was initially conducted in PubMed and then adapted for CINAHL, using different indexing methods to suit each database and maintain the consistency of results. Both searches were limited to 1st January 2010. The search strategy was refined through team discussions and the final search syntax is provided in appendix A.

Eligibility criteria

Inclusion criteria

Included studies were primary studies published between 01 January 2010 and 23 June 2023, of qualitative or mixed methods design, reporting on the implementation of EHRs in any health care setting, with end users of as study participants. Studies were included if they provided descriptions of engagement strategies used during implementation. Only studies in English were considered.

Exclusion criteria

Studies were excluded if their participants were only non-end users, or if they were reviews, meta-analyses, literature reviews or quantitative studies. By non-end users we mean individuals who do not directly use or interact with EHRs in their healthcare roles, which may include policy makers and managers. At final screening studies were excluded if they did not describe any engagement strategies used at any point during EHR implementation; there was no description of user involvement undertaken or attempted.

Study selection

All identified studies (n=1034) were checked for duplicates using the Zotero software. The remaining studies (n=963) were double screened by title and abstract using the Covidence software by three members of the review team (CZ, SA and SM), guided by the inclusion criteria. Full text screening was conducted by the lead reviewer (CZ), screening the first 20 studies, while FG and JG independently screened the same batches to ensure consistency of screening decisions. Beyond this point, CZ conducted full text screening of the remaining studies and discussed the screening decisions with the senior co-authors (FG and JG) to ensure consistency and accuracy of this process. This led to the final sample of included papers (n=41).

Quality assessment

The standards for reporting qualitative research (SRQR) was used as a quality appraisal tool, the lead reviewer (CZ) assessed the quality of the articles with the input of senior co-authors (FG and JG). The SRQR consists of 21 items which provide standards for reporting qualitative research (266). To adapt the SRQR for quality appraisal, we assigned a scoring system for each of the 21 items, scoring points for fully addressed items (1 point), partly addressed (0.5 point) and not addressed (0 point) (see appendix B). For mixed methods studies, we focused exclusively on the qualitative parts of the findings and applied the SRQR accordingly. We used the total score as an indicator of the quality of the paper. Thus, from a possible maximum score of 21 (see Table 2), studies that had a score lower than 15 out of 21 were regarded as low quality. They were retained if they met the inclusion criteria but we were cautious in use of evidence from lower quality papers. As this is a novel use of the SRQR, we additionally assessed the quality of papers using CASP checklist (see Appendix C). The CASP ratings provided similar quality ratings but with a narrower range of scores, limiting differentiation between studies.

Data extraction

The lead author (CZ) extracted data from eligible studies (n=41) into an Excel spreadsheet and word document. The details from each study were recorded and these include the names of authors, year of publication, participants, design, study setting/context, intervention characteristics, description of engagement strategies used and user perceptions on engagement

strategies (see tables 2 and 4). After this stage, JG and FG met with CZ to review the consistency of the extraction. All included studies featured engagement strategies, but only those providing detailed insights were incorporated into Table 4. These offer rich information on strategy implementation and user perceptions. Studies with less depth are only included in the results section text (See next section for how this was managed during analysis).

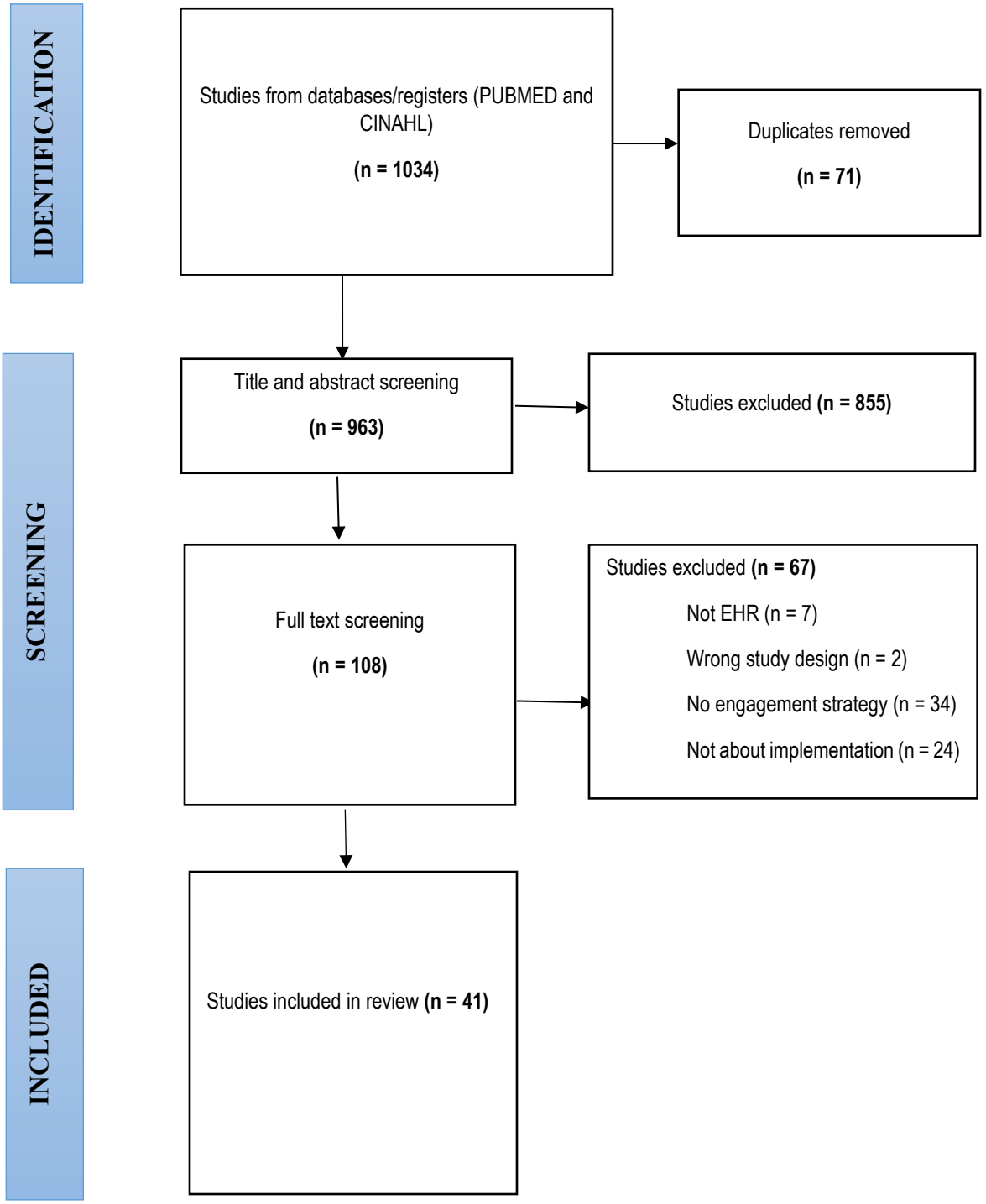
Data analysis

The results of all studies were inductively coded using descriptive themes in NVivo. Themes were grouped by type of engagement strategy (See table 3). The coded data from richer studies was interrogated to create table 4 which reports on the context of implementation (setting and scale of implementation), engagement strategies that were used at each stage of implementation (before, during and after implementation) and the success or failure of the strategies as reported in the paper. Papers reported success/failure as perceived by their research participants. We used the NPT constructs (coherence, cognitive participation, collective action and reflexive monitoring) to identify the reasons for the success or failure of each engagement strategy.

Through a qualitative comparative analysis (QCA) process, we compared the studies to identify what combination of context and engagement strategies resulted in successful engagement (see table 4). The QCA is a method for identifying the configurations of conditions that lead to specific outcomes (267). A narrative synthesis was then written, drawing in data from the papers beyond table 4 to provide diverse examples and avoid overlooking disconfirming results.

Figure 1: PRISMA flow diagram

FIGURE 1: PRISMA flow diagram describing identification, screening, exclusion and inclusion process



Findings

Description and overview of studies

The search yielded 1034 results, reducing to 963 after removing duplicates. From these, 108 were remaining after title and abstract screening, reducing to 41 after full text screening (see figure 1), with 36 qualitative and 5 are mixed methods studies. Quality assessment resulted in 21 high-quality (18-21/21) studies, 17 average-quality (16-17.5/21) studies, and 3 below-average studies (<16/21). We included all studies but found higher quality papers had richer and more useful data for our review.

Of the 41 studies, 38 were from high-income countries, 2 from middle income and 1 from a low-income country (See Table 2). Additionally, 13 studies were conducted in single units/facilities, 18 were multi-site or regional implementations, 7 were national implementations, and 3 were multi-national implementations. 23 studies were conducted in hospital settings, while the remaining 18 were spread across mental health, maternity, long-term care, nursing homes, ambulatory, teaching clinics and HIV care facilities. Among the 41 studies, 22 primarily involved nurses as participant users, while the other 19 had participants from various professions, including physicians, doctors, dentists, pediatricians, pharmacists, administrators, data capturers, and mental health practitioners. Of the 41 studies, 22 involved non-user participants: managers, software developers, engineers, heads of departments, case managers, quality improvement specialists, policy makers, researchers, software vendors, business and process analysts, safety officers, information officers and process architects.

Table 2: Description of studies

Author(s), Year	Country	Scale of implementation	Healthcare setting	Study Design	Participants	SRQR score
Abramson, 2012	U.S.A.	Single unit	Academic affiliated, hospital-based ambulatory internal medicine practice.	Qualitative	Physicians	20
Alzghaibi, 2022	Saudi Arabia	National	Primary Health Care Centers	Mixed	General Manager, Head of Department, Deputy Head of Department, Software Developer, and Analyst	20
Bristol, 2018	U.S.A.	Single unit	Hospital	Qualitative	Nurses	20

Author(s), Year	Country	Scale of implementation	Healthcare setting	Study Design	Participants	SRQR score
Chang, 2016	Taiwan	Single unit	Hospital	Qualitative	Nurses	18.5
Chipps, 2020	U.S.A.	National	Multi-state hospital systems, academic medical centers, teaching, community hospitals in urban areas, specialty hospitals, and rural and critical access hospitals	Qualitative	Nurses with expertise in EBP, nurse informaticians (NIs), quality improvement specialists, advanced practice nurses and nurse administrator	18.5
Costa, 2022	Brazil	Multi-site	Prison Health Care	Qualitative	Doctors and Nurses	15
Craven, 2013	U.S.A.	Multi-site	Hospitals	Qualitative	CEOs, Directors of Nursing and IT, Vendors of systems, consultants working in the EHR market, Critical Access Hospital staff members, National policy makers, Researchers in clinical informatics and health information technology policy.	16.5
Creswell, 2011	United Kingdom	National	Specialist hospitals	Qualitative	Implementation team, Junior and senior nurses and doctors, allied health professionals and administrative staff	19
Cucciniello, 2015	Scotland	Single unit	Teaching hospital	Qualitative	Clinicians, nurses, Medical Director, Chief information officer (CIO)	18
De Vliegher, 2010	Belgium	Single Unit	Home nursing organization	Qualitative	Head nurses, Administrators and Home nurses	18
Doyle, 2012	U.S.A.	Single Unit	Family medicine training practice	Qualitative	Physicians	17.5
Fernald, 2013	U.S.A.	Multi-site	Primary care practice including family medicine, general internal medicine and general pediatrics	Qualitative	Family medicine, and general internal medicine practitioners, general pediatrics, REC staff leadership, REC staff, including executive staff, QI advisors, technical analyst.	17
Furlong, 2016	Canada	Single Unit	Tertiary Hospital	Qualitative	Nurses	16.5
Gomes, 2019	Brazil	Multi-site	Hospital	Qualitative	Nurses	17.5
Grabenbauer, 2011	U.S.A.	Single Unit	Hospital	Qualitative	Academic practitioners, private practitioners, hospital and academic administrators	20
Gui, 2020	U.S.A.	Multi-site	Hospital and Specialist centers	Qualitative	Physician Champions	20.5
Halas, 2015	Canada	Multi-site	Teaching clinics	Qualitative	Physicians, allied health faculty, and residents	17
Holden, 2011	U.S.A.	Multi-site	Hospitals and Outpatient clinics	Qualitative	Physicians, health faculty, and family medicine residents	17.5
McAlearney, 2013	U.S.A.	Multi-site	Hospitals	Qualitative	Physicians	19
McAlearney, 2015	U.S.A.	Multi-site	Hospitals	Qualitative	Managers, IT personnel and staff, physicians in practice and in training.	20
McCrorie, 2019	United Kingdom	Single Unit	Academic Hospitals	Qualitative	Doctors and nurses of different grades, a hospital manager and a ward clerk.	20
Meigs, 2016	U.S.A.	Multi-site	Hospital	Qualitative	Physicians	17.5

Author(s), Year	Country	Scale of implementation	Healthcare setting	Study Design	Participants	SRQR score
Mishra, 2022	U.S.A.	Multi-site	Academic Medical Centers	Mixed	General physicians, family practitioners and paediatricians	18
Mohammed-Rajput, 2011	South Africa, Kenya, Rwanda, Lesotho, Tanzania, Uganda & Malawi	Multi-site	Resource constrained health care organizations (unspecified)	Mixed	Clinical providers, data managers, data assistants, system managers, administrators, nurses, supervisors, registration personnel, data entry personnel, reporting system developers, clinicians, physicians, researchers, vitals clerks, pharmacists.	16
Naratharaska, 2016	Thailand	Nationwide	Hospitals	Mixed	Physicians	17
Rantz, 2011	U.S.A.	Multi-site	Nursing home	Qualitative	Administrators, nurses and Nursing assistants	15
Rozenblum, 2011	Canada	National	Hospitals	Qualitative	Representatives from national and provincial agencies responsible for health information technology, quality/safety and public health agencies, health professional associations, and vendors of health information technology.	20
Scantlebury, 2017	United Kingdom	Single Unit	Maternity unit	Qualitative	Midwives, Doctors and Health care assistants	21
Schnall, 2011	U.S.A.	Multi-site	HIV Case Management Agencies and Designated AIDS centers	Qualitative	Case Managers	16.5
Schoville, 2017	U.S.A.	Multi-site	Long term care facility	Qualitative	Director of nursing (DON), nurses (i.e., RNs and licensed practical nurses), and certified nurse aides (CNAs).	16
Ser, 2014	United Kingdom	National	Mental Health hospitals	Qualitative	Nurses, psychiatrists, social workers and allied health professionals	19
Sheikh, 2011	United Kingdom	National	Hospitals and Specialist centers	Qualitative	Junior and senior hospital managers, implementation team members and IT staff, junior and senior doctors and nurses, allied health professionals, administrative staff, patients and carers.	19.5
Sherer, 2015	U.S.A.	Single Unit	Hospital	Qualitative	Physicians, clinical and non-clinical staff	17.5
Shiells, 2020	Belgium, Czech Republic and Spain	Multi-site	Nursing Homes	Qualitative	Occupational therapist, Social care supervisor, Nurse supervisor, Physiotherapist, Nurses, Care quality manager, Social worker, Home manager, Art therapist	19.5
Sieck, 2020	U.S.A.	Single Unit	Academic medical center	Qualitative	Physicians	20
Sittig, 2020	U.S.A	Multi-site	Clinics and Hospitals	Qualitative	Physicians, nurses, laboratory and radiology directors, information technology leadership, Chief Medical Informatics Officer (CMIO), and Chief Nursing Informatics Officer (CNIO)) and	15.5

Author(s), Year	Country	Scale of implementation	Healthcare setting	Study Design	Participants	SRQR score
					supporting staff, administrative leaders, and administrative support staff.	
Swanik, 2019	U.S.A.	Multi-site	Dental specialties (private practice, hospital practice, teaching, and public health practice)	Qualitative	Dental faculty staff	16.5
Terry, 2018	Canada	Multi-site	Family health practice	Qualitative	Family physicians, nurses, pharmacists and social workers and included practitioners (Advanced EMR users)	20
Topaz, 2016	45 countries	Multi-site	Dental hospital	Mixed	Nurses, health informaticians, pharmacists and biomedical engineers	16
Upadhyay, 2022	U.S.A.	Multi-site	Trauma hospitals, Academic medical centers, Medical clinics, Home health centers, and Small hospitals.	Qualitative	Physicians, hospitalists, nurse practitioners, nurses, and patient safety officers	17.5
Watson, 2023	U.S.A.	Single Unit	Hospital	Qualitative	Clinical informaticists, human factors engineers, business process analysts, process architects, requirements analysts, and business process re-engineers.	16

Table 3 gives a list of the all the identified engagement strategies, descriptions of each strategy, and references to studies reporting these strategies.

Table 3. Description of engagement strategies

Engagement strategy	Description	Studies
Communication of policy and vision	This involves articulating, through various means, a clear and compelling vision or plan for the implementation of EHRs, which may occur along with outlining policies that guide their implementation, ensuring alignment, understanding, and support from all stakeholders in the healthcare environment.	(268), (269), (270), (271), (272), (273), (274), (275), (242), (276)
Preparation for implementation	This is characterized by an early involvement of end users in system selection and co-design, along with the establishment of an implementation team, which aims to foster user engagement, ensure system alignment with operational needs, and facilitate a coordinated approach for the successful integration of systems within the organization.	(268), (269), (270), (276), (277), (278), (227), (279), (280), (281), (282), (283), (284)
Training and education	Involves the use of formal training methods to equip end users with the necessary skills and knowledge required for effective use of EHRs. This could include provision of learning material, on-site formal sessions, simulated practice and tailored training for specific user roles.	(269), (270), (271), (272), (274), (275), (277), (279), (280), (282), (284), (285), (286), (287), (288), (289), (290), (291), (292), (293),

		(294), (295), (296), (297), (298), (299), (300), (301)
On-demand technical support	This refers to the availability of IT personnel, online self-service systems, and informal learning opportunities through consultations from colleagues who are proficient users, to provide timely and varied assistance for users encountering technical challenges in EHRs usage.	(269), (270), (274), (227), (280), (285), (289), (291), (292), (296), (302), (303), (304), (305)
Ongoing engagement for user informed feedback	This entails a continuous process of communication with end users, encouraging feedback, and facilitating suggestions for modifications to the electronic health records (EHR) system, ensuring a dynamic and responsive approach to meet evolving needs and preferences.	(268), (270), (288), (295), (302), (306)

Before implementation

Engagement strategies used at this stage aimed to prepare facilities and end users for implementation beforehand.

Communication of policy and vision

Policies at national level were perceived as an effective way of communicating intention across multiple facilities and to foster buy in and collective action for stakeholders at various levels as one study reports: "*You need upper-management buy-in and buy-in from all department heads, including HIM director or materials management, not just top administration. Clinical and operational leadership must be engaged fully in the process*" (268). In most cases of national and multi-site implementation, policies and visions were generated at national level but facility leaders proactively made policy changes and provided support to users (242,269,270). Several studies show facility leaders playing this role in preparing and engaging users at this stage (227,242,270–272). Local facility managers should be able to engage end users according to their own managerial insights and organizational needs to ensure that users can make sense of the new system. Communicating the vision requires leaders to manage expectations for users as one study highlights: "*This is an organizational change project not an IT implementation project, and it will rise and fall on how much the leaders — all the leaders not just the CEO — understand and set and guide expectations*" (268).

However, in some cases policy and vision were communicated from the top but lacked engagement with local leaders leading to poor communication with end-users (227,271,273–276,284). For instance, where implementation was led by national structures without engaging users and leaders from local organizations, the vision was perceived as poorly communicated (227). In such cases, communication was in the form of a directive, which limited facility managers' autonomy to tailor implementation for their organizations. One study shows how this led to poor coherence and cognitive participation, as users perceived the EHRs as imposed: "*It's getting the users to understand and the hospital to understand that the system is theirs and they own it…The danger is they feel it's thrust on them and they have to use it.*" (271). Thus, local management struggled to communicate the policy and vision when national bodies used a top-down engagement approach. In another study, national bodies later tried to address this issue after users showed resistance: "*I think it's about what are we communicating, how we communicate that, what are we saying our expectations are to staff about what are the benefits of this system to patients and to staff*" (227). This was done through communication strategies, emphasizing anticipated benefits, training, appointing clinical leads, and seeking user input in system design.

Preparation for implementation

Engaging end users prior to implementation was deemed important, with local leaders playing a crucial role in translating the implementation vision into practical tasks (270,277). This enables sense-making, helping users understand the coming changes and their roles in it. One study reports how multiple sites minimized workflow disruption by conducting a 'readiness to change' assessment at facility and individual levels (269). This involved assessing issues such as current user IT usage in facilities and computer literacy to inform implementation plans. One study reports how preparation for implementation should involve collective action: "*Assembling the right team—usually the practice manager, a clinician, and staff members—to plan and implement this work was essential. We have put a team together that involves every area of the practice*" (278).

As shown in table 4, early preparation involves leaders proactively engaging users early, and involving them in vendor selection, planning and decision making stages

(227,269,270,279,280,283). This secures cognitive participation, fostering collective work towards a goal as one study reports: "*Across sites, informants emphasized the importance of early physician buy-in, with several sites noting that, ideally, the physicians themselves should drive the EHR adoption decision as opposed to the health system. Early and strong physician buy-in was deemed critical in order to ensure successful implementation and minimize resistance*" (269). Another study showed how early user involvement generates buy-in: "*participatory process in selecting the EMR system represents a distinctive way to generate and improve commitment to the project within the organization. Conversely, if this process is imposed, it can generate user frustration and have a negative impact on the implementation process and on the overall use of the system*" (280). Several studies showed that the overall benefit of early user participation is that users can select a system that meets their needs (269,270,276,281). One study suggests that learning from facilities with similar systems can further inform user choices: "*Take a group of staff to visit another hospital that has the system you're considering; observe how the system works, and ask to hear their stories about system build and use*" (268).

In cases of poor preparation, poor user cognitive participation was also noted. For instance, when national bodies imposed EHRs on users, local management struggled to prepare their facilities because they perceived it as an attempt to promote software that was not chosen by intended users (227). Such engagement allows early feedback from users, through reflexive monitoring. In one study, users tested the system but their feedback was largely ignored leading to a rollout of a system that malfunctioned (281). Similarly, in one facility, extensive user preparation included awareness road shows, on-site demos, training and e-learning before going live, but the system malfunctioned poorly as users could not communicate with developers for intelligent problem-solving (282).

During implementation

Engagement strategies used at this stage were aimed at supporting end users and managing challenges during the implementation process.

Training and education

Training and education were frequently reported in the findings. Studies shared user insights on training methods, timing, frequency, content and the delivery of training (275,285–287). Training that was reportedly successful was delivered a few weeks before going live (269), with one study cautioning against delaying EHR rollout after training as it may lead to users forgetting what they learnt (271). Training that came too early or too late after the rollout was reportedly unsuccessful (274,288). While timing was important for initial training, users felt that refresher training was particularly helpful following system upgrades (279,289,290).

Studies report various training methods: formal course training, simulations and practice, providing user manuals and leveraging highly trained users to train colleagues (277,282,291,292). Hands on and simulation training were favored by users because they allowed users direct interaction with systems (269,292,293). Users describe its usefulness in real-work situations: "*[The training should be] more applied by focusing on a patient scenario, to facilitate learning how to use the system safely and efficiently during a patient visit*" (294). In cases where users had varying levels of computer literacy, training started with basic computer education (292,295). In a nursing home study, users found it beneficial to supplement theoretical training sessions with manuals as they provided a convenient and quick reference: "*it is reassuring to know that you can always fall back on it [manual] when you have doubts about putting things in the right screen*", while another stated: "*a manual is necessary, especially in the weekends, when it is hard to contact someone*." (296). In other cases, training was supplemented by emails on lessons learnt and guidance for complex tasks (274,297).

Some users, did not favor formal training, and found it too generic to just sit and receive information on how to use the system from a trainer (292,298,299). In table 4, formal training was successful when supplemented with peer support and learning (280,285,286,295). Users also preferred hands on training and learning from peers more: *"[Training with technical support] was pretty useful [but] experimentation is number one and then being taught by colleagues*." (300). In such cases, proficient users who were peers and colleagues facilitated training tailored for their context for non-proficient users (269). This eliminated the need for users to leave their wards for more training or support (280). In one study, physician champions through reflexive monitoring noted that the training was too generic and developed a tailored simulated training environment

for users before going live, which was well received (285). However, in two studies, training was only offered to advanced users, neglecting the broader user base and leading to poor training outcomes among users (282,301).

Users preferred tailored training because it catered to their unique roles and workflows (272). Conversely, where training was not tailored, users found it irrelevant: ''*If you were an admin person, you've got a certain type of training…And so, you had people sitting in training session where maybe 50% of what was being trained was not really applicable to their job.*'' (271). Thus, failed training efforts were typically attributed to generic and untailored training approaches (271,301) which discouraged cognitive participation. Other challenges in training included inconsistent and insufficient training (283), as one study reports: "*Participants found EHR training to be superficial and of insufficient duration. Some obtained training for a few hours before using EHR for clinical activities. Some were trained as they performed clinical activities, and others got trained over the phone*" (287). Users noted that training was poor when delivered by individuals unfamiliar with the workflow or the specific work of users as they perceived that such trainers could not effectively bring coherence and cognitive participation among users (270). Users felt that training was also unsuccessful when imposed on them. In some facilities, users were reluctant to take time to learn until necessary, as some managers mandated training, requiring users to demonstrate competency before EHR use (269,270,282). However, this approach was perceived to be too intrusive and less effective in aiding users to make sense of EHRs.

On-demand technical support

Users appreciated real time, hands on, in person and on demand support during actual care situations (270). Some multi-site studies highlighted the effectiveness of real-time support (289,292,302), with one study emphasized the value of on-site developer assistance due to the convenience of developers' prompt availability (289). In this case, the on-site developer was available for user support throughout their work shifts (289). Another study achieved this by establishing direct contact with off-site developers who could remotely assist users: "*staff could write notes and feedback any problems directly to the developer, who also had remote access and could look into any issues quickly*" (292). However, slow responses could led to frustration, especially during urgent situations as reported in one large organization: "*Essentially, anyone can*

submit a ticket but as far as the response, I guess there are thousands of tickets so the ability of the organization to respond personally, you always get an automated response." (302). As a workaround, some users submitted their requests to their immediate supervisors, who escalated it up the '*chain of command*'. One nursing home required nurses to sequentially contact the administrator, head nurse, and IT manager to address problems (296) and issues were resolved on the same day.

On-demand support was also provided by super users, physician champions, and nurse informaticians (274,284,302,303). Physician champions were perceived to be effective in providing localized support during critical periods, a month or two after the system's implementation. Similarly, another study made use of nurse coordinators for this task: "*Our nurse coordinators who served as super users...really knew the system and were adept at helping their colleagues and physicians*." (285). In this study, external people were also hired to provide extra support on a part time basis (285). Where nurse informaticians (NIs) were used, they initially facilitated implementation and continued to provide user support after, with some NIs directly embedded with the IT team, and others in the nursing department (302). Although NIs were understaffed, users found them useful in promoting system use. In other cases, similar roles were fulfilled without specific titles, where a team of proficient clinicians acted as knowledge resources and were strategically positioned in wards (227,280,284).

On-demand technical support was perceived as more effective when provided by peers as they leveraged existing relationships and were often influential enough to garner the trust of other users. However, when these roles were imposed or incompatible with user workflow, there was limited success (227). Several studies underscore the importance of providing well trained support personnel (269,291,304). In one case, IT support personnel were slow in responding to problems causing delays and user frustration: "*IT personnel need to quickly assist us in resolving problems… If the problem remains the same, how can you expect us not to have negative emotions toward this system?*" (305). Poor support led to users disengaging: "*In fact, we are not uncooperative with the hospital's policy to use technology. We only hope for more support during the adaptation period. Our workloads remain the same, and adapting to the new system is an additional task, which is exhausting.*" (305).

After implementation

Strategies implemented at this stage were aimed at sustaining user involvement by addressing ongoing needs and improving the system.

Ongoing user engagement

Ongoing engagement ensures continued use and improvement of EHRs through reflexive monitoring, especially when introducing system upgrades, changes and adding new features as users need to be informed about these changes.

Users perceived that channels for continuous user feedback are useful for making informed improvements, with effective channels involving bi-directional feedback (268). In one study, sites used different engagement approaches for bi-directional feedback, with some through staff meetings, emails, an open-door policy, and by allowing direct communication with the Director of Nursing (DON) (270). Users from this study found this to be an effective way of engaging as leaders would relay back the outcomes of their input back to them. Another study showed that effective ongoing engagement was through regular meetings of physicians from various specialties in EHR-focused committees (295). This approach, through the collective action of various users, ensured the input of diverse perspectives for planned upgrades and changes.

Facility leaders played an important role in establishing communication channels, and users reported favorably towards positive communication: "*Leadership communication strategies about implementation were mostly positive and supportive to the user…All groups reported a range of communication strategies, including education manuals, direct communication, e-mails, cheat sheets, and auditing.*" (270). In another study, nurses who were intermediaries during implementation also facilitated this communication: "*We have frequent updates [EHR system], guided by nurses who have become part of the program. Our system therefore has become close to exactly what we need…I contact one of those nurses who usually make [sic] it happen*" (288).

Although updates were appreciated, users preferred receiving periodic updates, communicated through regular staff meetings with developers: "*What I think would be really helpful is sort of periodic updates in various forms. If there's going to be a massive change or update…if they could come to our division meeting, department meetings, probably division meeting, or even our*

clinics." (295). Some users preferred less frequent email updates and admitted to ignoring non-urgent emails due to email fatigue: "*I hate to say it that way, because we get, there's email fatigue, too…A lot of times I don't even open 'em. I delete a lot of stuff. You just gotta' focus on stuff that seems relevant for the moment to get you through the day*." (295).

However, users in large organizations faced challenges with complex organizational layers to provide feedback: "*Now that we are part of a larger system, making those changes, just go into layers and layers of people to get those changes*." (302). Thus, ongoing engagement can be complicated by organizational size and can lead to user frustration (306).

Use of engagement strategies

Table 4 shows that successful implementation requires the use of multiple strategies concurrently. A contrast can be made between the Cucciniello (280) study, which used 4 strategies and can be seen as more successful, against the Bristol (288) study, which used 2 strategies with less success. In the Cucciniello study (280), implementation was more successful because users were involved and prepared early, offered training and support through peers, and a phased implementation approach was used to allow for real time adjustments during rollout. This ensured user coherence and cognitive participation through early involvement, followed by collective action and reflexive monitoring through peer led training and support. In contrast, the Bristol study (288) reports only training and ongoing engagement after rollout, leading to a poor implementation due to poor coherence and late training, rendering it ineffective.

Users perceived that another important success factor for engagement strategies is the capacity for reflexive monitoring. Studies that were reportedly successful were able to revise, and adapt where necessary due to feedback from user groups such as super users and champions (280,285), representative groups (295), online platforms (302) and direct engagement with users (270). The constant monitoring and dynamic responsiveness led to a more successful use of engagement strategies and a more resilient implementation.

Discussion

Our findings show that effective communication of policy and vision is crucial for user buy-in as a top-down approach without user participation may result in poor outcomes. Preparation for implementation and early user involvement in decision-making processes are effective engagement strategies prior to implementation. This involves assembling a diverse and representative team to facilitate implementation. Tailored training, especially through simulated practices, accommodates diverse user roles, workflows, and user literacy. However, critical factors for training effectiveness include timing, content and methods used. During rollout, on-demand support from technical personnel and proficient peers is crucial engagement to promoting EHR adoption. After implementation, ongoing engagement sustains a successful EHR adoption and optimization process through user feedback and active participation.

Similar to our findings, reviews emphasize the importance of user involvement for user readiness and better adoption (307). Reviews report on the effectiveness of individual or clusters of engagement strategy reported in our study. Policies are crucial in fostering user readiness. One review shows that in developed and developing countries, policies were key determinants of readiness for EHR implementation (308). Involving users early in the co-design of EHR systems has proven effective in improving implementation by ensuring the system caters for user needs, minimizing workflow disruption (309). Another review demonstrated how tailored training, before, during and after EHR implementation is effective, especially when it includes super users, peer to peer and a mix of different training methods (310). Successful adoption of digital technologies in clinical settings often hinges on organizational support, including that of personnel such as physician champions (311). Ongoing formal programs of peer support groups, and online tools was reported to be an effective way of continuing to engage users (312).

WHO resolutions on digital health implementation encourage governments to develop strategies that guide implementation (169). While global EHR adoption is rising (170), many studies in this review focus on high-income countries (See Table 2). Several middle-income countries such as China, Brazil, India and Mexico have initiated their EHR adoption, but most of them are still in early stages primarily due to financial and technological challenges (44,234). This review draws insights from counties that have implemented EHRs to aid those in early stages. Low and middle income countries face challenges when implementing an EHR challenges including financial

constraints (313). This review synthesizes learning that can contribute to implementation success and the avoidance of costly failures of implementation such as that in England in the 2000s (314).

Successful implementation is important because of the stress caused to health-workers during implementation due to heightened uncertainty (315). Effective engagement strategies can reduce this stress (316). Evidence suggests that user stress can be reduced through tailoring EHRs to clinicians' needs, conducting usability testing and providing ongoing support (317). High levels of EHR related stress have been linked to an increased intent among clinicians to leave their clinical practice (318). Low- and middle income countries already face challenges in retaining their clinical workforce (319). User engagement during implementation of an EHR can help retain the clinical workforce. Engagement strategies remain necessary even after implementation to keep clinicians motivated and promote mature use of EHRs (320).

Implications for research, policy and practice

This study underscores the importance of user engagement in implementing EHRs and identifies effective strategies along with the underlying reasons for their success. Inclusion of user engagement within policy can enable implementers to give priority to user engagement during implementation. This evidence review can inform implementers decisions on how to engage users, when and why. This is particularly important for low- and middle-income countries now considering the roll out of EHRs to support universal health coverage, where costly failure needs to be avoided.

Recommendations

The table below outlines recommendations drawn from the study findings on effective engagement strategies for EHR implementation, offering guidance on when and how to apply engagement strategies.

Table 5. Recommendations from study findings

Before implementation	<u>Communication of policy and vision</u> • Effectively communicate the vision of EHR implementation through a two-way engagement with users and proactively implement policy changes beforehand. <u>Preparation for implementation</u> • Involve users in decision-making stages and create designated teams from user ranks to aid in the implementation process for increased buy-in. • Facility leaders should guide the implementation process and translate the vision into practical tasks to users.
During implementation	<u>Training and education</u> • Training and education are necessary and should be timely, incorporating hands-on and simulation methods, and tailored to users' roles • Successful training involves avoiding generic and untailored approaches, considering diverse user needs, and supplementing formal training with peer support. <u>On-Demand Technical Support:</u> • Implement post-training support mechanisms, including real-time assistance, to enhance user experience and adaptation. • Establish specific roles such as super users, physician champions, and nurse informaticians to provide on-demand support, prioritizing peers for effective assistance. These roles should be filled by individuals who are well trained and prepared.
After implementation	<u>Ongoing user engagement</u> • Establish diverse and effective ongoing engagement channels, including bi-directional feedback and EHR-focused committees, led by facility leaders and supported by intermediaries, to enhance user involvement and system improvement. • Address challenges in large organizations by streamlining communication, and provide periodic updates for major system changes

Strengths and limitations

A notable strength of the study is that it builds on two existing reviews by Mair and Ross (54,55), which enhances the relevance and amplifies some of the findings from earlier reviews. However, the rapid review's limited search on PubMed and CINAHL only may have constrained our findings, potentially missing other information that may be captured by a more extensive search. The lead author (CZ) carried out the data extraction alone, however, the lack of cross checking at this stage was mitigated by supervisors, who checked for accuracy and consistency in the process and methodology.

Conclusion

In conclusion, this study highlights the importance of user engagement for successful EHR implementation. These strategies include communication of policy and vision, preparation for implementation, training and education, on-demand technical support and ongoing user engagement. The strategies are effective at different stages of implementation and need to be aligned with user coherence, cognitive participation, collective action and reflexive monitoring.

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Table 4: Evidence synthesis of results from 16 studies

Study	Scale	Stage	Engagement strategy	Successes, challenges and solutions to strategies	NPT constructs				Outcomes
					Coherence	Cognitive Participation	Collective Action	Reflexive Monitoring	
Cucciniello, 2015	Single unit	Before	**<u>Preparation for implementation</u>** Users were involved in choosing the system through a workshop where they chose from different software vendors	<u>Successes</u> Due to the user centered approach, users became advocates of the system and were actively involved throughout the implementation process	Yes	Yes	Yes	Yes	**Successful**
		During	**<u>Training and Education</u>** An implementation team trained super users. Key users and super users were appointed as local facilitators to support and train other users.	<u>Successes</u> Super users' were useful as users were no longer required to leave their wards for training or to get help.	Yes	Yes	Yes	Yes	**Successful**
			<u>On demand technical support</u> Clinical advisors internally recruited to assist with supporting implementation and were responsible for conceptualizing, developing and administering training and service delivery, and providing technical input. A team was established that met once a month to provide help where needed.	Successes The support started informal but grew past implementation to picking up on user mistakes and showing them how to correct them.	Yes	Yes	Yes	Yes	**Successful**
			<u>Ongoing engagement for changes required</u> Implementation was structured, starting with the most relevant functions in the facility, followed by piloting additional functions in single wards in order to test them and to get feedback from staff working on the selected wards.	<u>Successes</u> This helped make any adjustments based on results and the progress made when using the system.	Yes	Yes	Yes	Yes	**Successful**
Gui, 2020	Multi-site	Before	**<u>Training and Education</u>** User training prior to going live	<u>Challenges</u> • Only offered to physician champions • Training was too generic, and not tailored to depts' contexts • Took place after the champions had to customize the system • No live or simulated practice <u>Solutions</u>	Yes	Yes	Yes	Yes	**Successful**

				Champions developed training with simulated environment for own department					
		After	**<u>On-demand technical support</u>** 'At the elbow' support after going live	<u>Challenges</u> • Support was insufficient • Champions tried to communicate with system builders but failed <u>Solutions</u> • Champions sought help from super users or hired in external people • Champions facilitated peer support	Yes	Yes	Yes	Yes	**Successful**
Chipps, 2020	Multi-site	During	**<u>Preparation for implementation</u>** Nurse Informaticians (NIs) acted as advocates for system use. Some NIs were embedded with the IT team while others were in the nursing department.	<u>Successes</u> NIs were highly valued. <u>Challenges</u> A high volume of work shifted to the NIs and they were understaffed.	Yes	Yes	Yes	No	**Successful**
		After	**<u>On-demand technical support</u>** An online self-service request system for staff users to make contact developers on EHR issues. This system was posted on the organization's internet page so all staff had easy access to it	<u>Successes</u> Self-service request system was viewed favorably <u>Challenges</u> • High volume of tickets due to the organization's size led to slow response. • Some users submitted a request to an immediate supervisor with limited success	Yes	Yes	No	Yes	**Successful**
Holden, 2011	Multi-site	During and After	**<u>Training and Education</u>**	<u>Successes</u> • Initial formal training was depicted favorably by some,	Yes	Yes	Yes	No	**Successful**

			There was formal training for users followed by informal support where users learnt from their colleagues	• Many physicians said they were better able to use EHR from talking to and observing colleagues using EHR. <u>Challenges</u> • Training was often insufficient and the classroom style was ill suited for users • Physicians preferred hands-on, in-person training provided in practice rather than formal training					
			<u>On demand technical support</u> Technical support facilitated use both in the initial days and weeks of EHR and afterwards.	<u>Successes</u> • Support staff were generally perceived as knowledgeable and helpful • Physicians were most appreciative of one-on-one, on-demand support during actual care scenarios. <u>Challenges</u> Support staff were unavailable sometimes (off hours and holidays).	Yes	Yes	Yes	Yes	**Successful**
De Vliegher, 2010	Single Unit	During	**<u>Training and Education</u>** Home nurses received manuals prior to actual use of ENR. There was no manual in one of the departments. All users received 2 sessions of 4 hours education. First session was theoretical. In second session nurses received a fictitious list of patients to try out the different screens.	<u>Successes</u> • Manual was appreciated as users could always fall back on it when they needed help. • Manual was necessary, especially on weekends, when it is hard to contact someone. • Education was viewed as necessary and useful by users	Yes	Yes	Yes	Yes	**Successful**
			<u>On demand technical support</u> Nurses first contacted the administrator with queries. If they could not resolve the query it was passed to the head nurse, and then if necessary to the information technology (IT) manager.	<u>Successes</u> Users reported having adequate support and problems were solved usually on the same day	Yes	Yes	Yes	Yes	**Successful**

Sieck, 2020	Single Unit	During	**<u>Training and Education</u>** Tailored training was provided to cater for different user roles and physician representatives shared training strategies based on what was done in other units. Users also learnt from colleagues through observations and sharing of tools.	<u>Successes</u> • Tailored training helped users to adapt as it was more specific to their roles • Learning from colleagues improved the initial training, which was often generic.	Yes	Yes	Yes	Yes	**Successful**
		After	**<u>Ongoing engagement for changes required</u>** • Department representatives participated in EHR-committees. • System changes were communicated to users primarily via emails	<u>Successes</u> Physicians were represented and included in the modifications and decision making process	Yes	Yes	Yes	Yes	**Successful**
				<u>Challenges</u> • Some users preferred periodic updates for massive updates communicated via staff meetings • Emails were too frequent causing fatigue and users ignored some of the emails	No	No	No	No	**Unsuccessful**
Schoville, 2017	Multi-site	Before	**<u>Preparation for implementation</u>** Leaders in one site involved users in vendor selection.	<u>Successes</u> Leadership was available for support in all sites from the beginning, and there was good teamwork.	Yes	Yes	Yes	N/A	**Successful**
		During	**<u>On demand technical support</u>** Super-users were appointed at all sites. These were individuals who were most knowledgeable about the system and available to assist with troubleshooting users' calls and questions	<u>Successes</u> Super users were useful and assisted with troubleshooting users' calls throughout implementation.	Yes	Yes	Yes	Yes	**Successful**
			<u>Training and Education</u> Education and training sessions in formal classroom settings, competency testing, and a practice playground environment. Information was also shared through education manuals, direct communication, e-mails, and cheat sheets.	<u>Successes</u> Communication strategies were mostly viewed as positive and supportive by the users. <u>Challenges</u> • Training was insufficient and inconsistent as educator was not a nurse and did not understand user workflow	No	No	Yes	No	**Unsuccessful**

				• Users needed real scenarios with training. • Staff at one site reported threats of punishment being used with problem solving.					
		After	**Ongoing engagement for changes required** Auditing across sites to keep leadership informed about EHR use. Some sites' strategies included bi-directional feedback, seeking it in staff meetings, e-mail, and open-door policy with employees.	Successes • Feedback enhanced problem solving especially when facility leadership communicated the outcome of the comments.	Yes	Yes	Yes	Yes	**Successful**
	Multi-site	Before	**Preparation for implementation** EHR adoption decision was communicated across all sites and the vendor selection process was done by management and IT personnel	Challenges • Lack of early physician buy-in, with several sites noting that, ideally, the physicians themselves should drive the EHR adoption decision as opposed to the health system. • Users should have been part of the vendor selection process to ensure that the product selected could support their clinical needs/preferences.	No	No	No	No	**Unsuccessful**
		During	**Training and Education** Formal training was provided prior to going live. All physicians were required to participate. In one organization, physicians had mandatory e-learning requirements and then had to demonstrate competency with basic EHR functions before they could use the new EHR system for patient interactions.	Successes • The most successful trainings were conducted within a few weeks of go-live. • Physicians found it useful to get an opportunity to "play around" with the system prior to going live • Although time-consuming, many sites reported that having physicians abstract their own charts and "preload" data was an important part of the training process.	Yes	Yes	Yes	Yes	**Successful**
			On demand technical support Support was provided after the going live period and most sites offered on-site IT support (vendor and/or internal IT) during the go-live period to answer questions and help troubleshoot on the spot.	Successes • The support team was capable and an essential facilitator • In-person support was particularly well received by	Yes	Yes	Yes	Yes	**Successful**

McAlearney, 2013

				physicians anxious about the transition to the EHR.					
Sittig, 2013	Multi-site	Before	**Preparation for implementation** User testing was done prior to implementation, a process that was led by vendors	Successes Users shared that they were able to test the system thoroughly Challenges • Only a select few did the testing • User feedback was largely ignored, thus the implemented version came with malfunctions	No	No	No	No	**Unsuccessful**
		During	**On demand technical support** Personnel to support EHR implementation and use. This was in the form of a multidisciplinary team of people capable of assembling all the required hardware and software components of the EHR, configuring these components, and deploying them throughout the organization. They worked with health facilities a year before going live	Successes Users regarded the team as key personnel to safe EHR use	Yes	Yes	Yes	Unknown	**Successful**
Terry, 2018	Multi-site	During	**On demand technical support** Advanced electronic medical record (EMR) users as an agent of change. They acted as motivators of change, mobilizing team members to come on board with activities such as data standardization and workflow changes, which would support advanced EMR use.	None mentioned	Yes	Yes	Yes	No	**Successful**
			Training and Education Electronic medical record training and education.	Challenges • Training and conferences were only offered to advanced users Solutions • Participants recommended non-advanced EMR users receive training and attend user conferences, and to consult with peers who were more advanced.	No	No	No	No	**Unsuccessful**

				Some suggested that newer users attempt problem solving within the EMR, thus engaging in experiential learning.					
Scantlebury, 2017	Single Unit	Before	**Communication of Policy and Vision** Policy changes leading to new audit requirements	Challenges • Vast amounts of 'top-down' in policy change Long-term staff, impacted by a previous failed system, were skeptical and did not differentiate between the two systems.	No	No	No	No	**Unsuccessful**
		During	**Training and Education** Management offered supplementary resources, extra training, 'lessons learned' emails, and electronic guidance for complex tasks	Challenges • The delivery of training was too simplistic and dogmatic • Training was inconsistent and varied in content and duration (ranging from none, a single 30 min or all day sessions) • Timing of training was too far in advance of, or after implementation)	No	No	No	Yes	**Unsuccessful**
			On demand technical support A support team of super users was appointed to help staff in using the EHR	Successes Super users were useful particularly for those with poor computer literacy. Challenges The team had limited availability (Weekday office hours only)	Yes	Yes	Yes	Yes	**Successful**
Creswell, 2011	National	Before	**Communication of Policy and Vision** The government shared a vision of national EHRs via targeted communication from the national bodies to hospital managers, and to users, stating expectations of the staff and the benefits of the system. This was done to mitigate a recognized risk of users refusing to use the new system and to win over skeptical staff	Successes Users generally bought into the vision of EHRs. Challenges Some hospitals did this effectively and others didn't, leading to an enforced use of the system by withdrawing the paper system	No	No	Yes	No	**Unsuccessful**
			Preparation for implementation National bodies withdrew existing paper systems to force use of EHR.	Challenges • Hospital management trying to 'sell' software that it had not	No	No	No	No	**Unsuccessful**

				chosen to clinical and administrative staff. • Early release software had limited functionality making it difficult to demonstrate the product to potential users					
		During	**<u>On demand technical support</u>** Centrally appointed national, and locally appointed clinical, champions	<u>Successes</u> Locally appointed champions were effective communicators between management and clinic groups and were valued by system users and hospital management.	Yes	Yes	Yes	Yes	**Successful**
				<u>Challenges</u> The centrally appointed national champions lacked credibility and couldn't facilitate effective two-way communication between mx and users.	No	No	No	No	**Unsuccessful**
Rozenblum, 2011	National	Before	**<u>Communication of Policy and Vision</u>** National bodies shared an E-health plan, a comprehensive national approach for health information technology	<u>Successes</u> Some parts of the E-health plan was generally viewed as successful <u>Challenges</u> • There was a lack of an e-health policy to foster effective strategies for adoption by clinicians. • The plan had inadequate attention to clinicians as key users of EHRs, which was viewed as critical • It needed to be more flexible and adaptive to accommodate user feedback	No	No	No	No	**Unsuccessful**
Ser, 2014	National	Before	**<u>Communication of Policy and Vision</u>** Local management communicated the vision of national EHRs to users	<u>Challenges</u> Hospital leaders: • did not understand the views of the mental health clinicians, who are the end-users • hadn't communicate successfully to their staff how EHR systems fit into a wider	No	No	No	No	**Unsuccessful**

				vision of improving patient care and efficiency in the NHS					
		During	**Training and Education** User training prior to implementation	Challenges • Lag time between training and implementation was too long • Training not tailored sufficiently to users' needs	No	No	No	No	**Unsuccessful**
McCrorie, 2019	Single unit	Before	**Preparation for implementation** User preparation involved road shows for awareness, on-site demos, training, e-learning, and additional training for designated 'EHR friends' or 'super-users' for the 'go-live' weekend.	Successes The preparation allowed users to identify areas of concern prior to implementation Challenges • Some participants (those not involved in EHR set-up) were concerned that the potential for intelligent problem solving was missing. • No direct communication with developers. • Perceived complex chain of command hindered customization transparency in the system.	No	No	Yes	No	**Unsuccessful**
		During	**Training and Education** Training was done as part of the preparatory efforts for implementation	Challenges • Training was not enough, or was found to be too intense or generic. • Training inadequately addressed generational differences in computer literacy. • Limited access to play domains.	No	No	Yes	No	**Unsuccessful**
Bristol, 2018	Single Unit	During	**Training and Education** The organization provided users with hardware and training	Challenges • Lack of training before implementation, thus it came late	No	No	No	No	**Unsuccessful**

				• Shortage of hardware (computers) to facilitate training • There was poor organizational support of the training process					
		After	**<u>Ongoing engagement for changes required</u>** There was communication between EHR users and EHR designers	<u>Challenges</u> • The organization overlooked the unique perspectives of nurses. • Nurses were frustrated due to a lack of attention from EHR system designers, leading to systems poorly equipped to address workflow issues.	No	No	No	No	**Unsuccessful**

CHAPTER 8: Discussion

This chapter critically examines the findings of the three main papers and presents an integrated account of the barriers and enablers to the implementation of EHRs in South Africa. Paper 1 begins by mapping the broad system level barriers and facilitators in South Africa and shows how governance, infrastructure and resources shape the foundation for EHR adoption. Paper 2 deepens this analysis by looking at a case study of a stalled implementation of an electronic tick register, revealing how the systemic barriers identified in Paper 1 translate unto practical failures. It also highlights how current gaps in leadership, accountability and coordination in South Africa's healthcare system exacerbate the implementation risks. Paper 3 extends the lens beyond South Africa by synthesizing the international evidence on effective ways of improving EHR adoption rates in health care facilities. As such, the paper explores effective user engagement strategies for EHR adoption, offering insights into mechanisms at individual and organizational level such as leadership buy-in, co-design and policy incentives. The insights from Paper 3 could mitigate some of the challenges identified in Papers 1 and 2.

Together, the three papers go beyond highlighting the problems, failures and potential solutions to EHR implementation in South Africa, by further demonstrating the interplay between systemic weaknesses and context specific dynamics. This provides a basis for a comparative critical analysis into how evidence from other settings can be adapted to South Africa's realities. Our findings show that implementing EHRs in South Africa is not a straightforward process but rather a multifaceted endeavour with a complex interplay of factors presenting as tensions and trade-offs worth considering. The tensions, which are presented competing interests and priorities, often arise from conflicts between stakeholders, resource limitations and institutional capacities, which significantly impact implementation outcomes. Trade-offs on the other hand, represent the compromises made in balancing and managing the competing demands. This can sometimes be achieved by prioritizing certain objectives at the expense of others. Therefore, a comprehensive understanding of these nuances is essential for developing effective strategies and policy decisions for EHR implementation. This section distils the main themes from the 3 papers in the results chapters and critically explores the possible strategies for balancing tensions and trade-offs in the implementation of EHRs in South Africa.

8.1 Top down versus bottom-up implementation

A persistent tension in EHR implementation is the ongoing debate between top-down and bottom-up approaches. High-income countries such as Switzerland, have generally managed to keep to pace with policy updates that promote the adoption of digital health technologies including EHRs (321). Government policies and legislation are also responsible in determining whether implementation follows a top down or bottom-up approach. For instance, early adopter countries such as the United States introduced legislation such American Recovery and Reinvestment Act of 2009, which gave financial incentives to clinicians and hospitals which accelerated EHR adoption (322).

As paper 1 shows, South Africa has kept to pace with policies that promote digital health and EHR adoption such as the national digital health strategy (2019-2024) (222). However, while policies set the framework, implementation largely occurs at the provincial level, where provincial capacity and subsequently their effective autonomy may vary considerably (323). As paper 2 further shows, at the district level, EHR implementation is also regulated by the provincial governments, which can lead to decision making tensions on system adoption and plans for sustainability. This reflects broader challenge of balancing coordinated, top-down directives with localized, bottom-up implementation. Although the top down is useful in establishing standards for system procurement and use, this approach alone can be prone to failure because it often neglects user buy in. Moreover, top down processes alone may not fully account for the realities of user workflows and unique operational challenges (202).

Conversely, bottom-up development is inherently more responsive to local needs, making user adoption and embedding efforts easier. However, as paper 2 shows, a bottom-up approach that lacks adequate support from the top can lead to integration challenges, funding shortfalls and limited scalability (324). Thus, without alignment with national and provincial efforts, bottom-up efforts risk becoming isolated silos, with long term sustainability challenges.

Instead, a ‘middle out approach’, offers a more balanced solution, integrating the national vision, policy guidance and system standards while allowing for flexibility to address local needs at provincial and district levels (202,239). This approach requires building consensus around a strategic vision, which is essential for large scale implementation of EHRs in South Africa (325). Thus, a middle-out approach in South Africa should blend top-down and bottom-up strategies, ensuring that while national and centralized systems can be implemented from the top, bottom-up efforts such as the e-tick can also be supported, as both approaches can be complimentary.

Encouraging diversity in EHR systems also fosters innovation and enables the development of tailor made solutions suited to different health care settings (241). Following the Western Cape province's approach, South Africa can adopt various systems, often doing different tasks, followed by a gradual integration of existing systems, a non-disruptive way. This approach has been successfully applied in Germany, the Netherlands, Switzerland and Canada (80), as well as Morrocco, a more recent third world adopter of this approach (326). In all these cases, balancing competing interests among different stakeholders and interests was an essential driver behind the adoption of this strategy. Thus, regardless of whether the initial approach was top-down or bottom-up, a middle out approach can be achieved through the convergence of interests.

8.2 Skills and capacity in the public health sector

South Africa has a strong base of skilled professionals in digital health, yet majority of them are disproportionately concentrated in the private health sector (327). This imbalance highlights the need for strategies to facilitate the skills sharing and transfer between the two sectors to bridge the gap. One potential solution is to establish greater collaboration between the public and other stakeholders such as private sector players. More specifically, this could be achieved through structured skills-sharing initiatives, public-private partnerships (PPPs), and incentivized career pathways that encourage digital health professionals to contribute their expertise to the public sector (328,329). Such collaborations have been widely endorsed in literature as a means to improve health initiatives such as digital health where they are resource intensive and requiring innovation (330). Through leveraging expertise from multiple sectors, South Africa can ensure a knowledge transfer that sustains digital health efforts such EHRs. In low to middle income countries specifically, governments have become increasingly more interested in involving the private sector in project financing, innovation and development (331).

Participants from paper 1 highlight how the private sector and other stakeholders such as NGOs have been gradually moving away from working with the government due to past scandals of corruption. This has made it volatile situation to work with the government. This has strained the relationship between government and key stakeholders, ultimately affecting the possibility of a collaborative approach to EHR implementation with much needed partners such as the private sector. The private sector has already made significant progress in EHR adoption for private care while many public healthcare facilities continue to rely on fragmented, or paper-based systems (332). Moreover, partners such as NGOs have already been involved with developing systems for public health use such as the Tier.net (for TB and HIV) to provide care

for patients in high disease settings (333). Similarly, paper 1 shows the various EHR systems in use and the collaborative efforts that went into developing and sustaining them, while paper 2 shows how the e-tick system was supported and driven by NGO involvement.

Therefore, the lack of collaboration between the government, private sector and other stakeholders represents a missed opportunity for leveraging advancements in digital health. However, in some cases, stakeholders may avoid partnering with the government for various reasons which include corruption as paper 1 shows, which is a key deterrent impacting public health efforts such as implementing EHRs in South Africa (334).

Corruption in South Africa's public health sector is well-documented, with widespread instances of fraud, mismanagement, and unethical procurement practices undermining health initiatives (335,336), which sometimes leads to political unrest (337). The abuse of tender processes, financial mismanagement, and politically motivated appointments often lead to the abuse of resources. Instead of directing funds towards capacity-building programs and health systems strengthening, funds are frequently lost through corruption and mismanagement, leaving healthcare facilities unprepared to adopt digital systems effectively. Moreover, leadership appointments in public health are often based on political connections rather than technical expertise, which results in ineffective decision-making, a lack of strategic vision and poor oversight (236,338). Without leaders who understand digital health systems, implementation efforts face delays, inefficiencies, and resistance to necessary reforms. As such, this not only erodes stakeholder confidence but also weakens the likelihood of having successful government led initiatives such as implementing EHRs.

To align public sector leadership with the goal of effective EHR implementation, South Africa needs to take decisive steps to address corruption and strengthen governance structures (339). The national development plan of South Africa also proposes strategies to strengthen civil service. These include ensuring transparent procurement processes, independent auditing, and stricter oversight to prevent the misallocation of digital health resources (340). Moreover, leadership positions must be filled based on expertise and merit, for ethical leaders with a strong emphasis on digital health literacy to drive evidence-based decision-making (339,340). Additionally, investing in technical training for public health workers, including IT specialists, healthcare informaticians, and data analysts, can ensure that the sector has the necessary capacity to manage EHR systems effectively. Strengthening the institutional and human resource

capacities is essential for ensuring that EHRs are implemented but this further requires a closer account of the various dimensions and actors involved (341).

8.3 Decision making and competing financial priorities

Implementing EHRs is a resource intensive commitment, and while it can be a highly rewarding investment, MICs like South Africa need to ensure that implementation follows well-structured strategies as resources are limited (342). This requires decision makers to be aligned with the vision of prioritizing digital health as a national imperative. South Africa is well positioned to invest in EHRs but resource allocation has been dismal. Digital health initiatives have not been prioritized and past corruption scandals, inefficiencies and abuse of the tender system have eroded trust in the government's ability to manage large scale projects such as implementing national EHRs (343). This mistrust has discouraged collaboration with key stakeholders and has contributed to resistance of top-down initiatives. To address these challenges, transparency and robust user engagement, as highlighted in papers 2 and 3, are critical for rebuilding trust. This can be further promoted by establishing independent, multidisciplinary and diverse committees with expert panels for objective decisions that are free from political interference (344).

When contrasted with other LMIC experiences, South Africa's case reveals both common and distinctive features of EHR implementation. Similar to South Africa, other lower to middle income countries such as Kenya, Uganda, Ghana and Nigeria have experienced fragmented system development, with some similarly driven by donor investments in vertical disease programmes (23,345). In India, infrastructural weaknesses and uneven capacity across states/provinces have produced highly variable outcomes (23,346). However, South Africa has a relatively advanced provincial data system in the Western Cape, which demonstrates the technical feasibility of integrated digital platforms; and the National Health Insurance (NHI) reform, which positions EHRs not only as technical tools but also as political symbols of health system transformation (142,178). These comparisons reinforce that while South Africa shares many of the structural constraints of other LMICs, its political and institutional context can break the mould to shape the trajectory of EHRs in unique ways.

Investing in EHRs can sometimes compete with other immediate or long-term health needs, as demonstrated in paper 2, where the Covid-19 pandemic delayed the progress of the e-tick system. Moreover, the federal structure, with provinces independently managing health care spending, creates tensions between centralized and decentralized implementation. This has led to the fragmentation of systems as mentioned in paper 1, which may hinder the interoperability

of systems for a unified EHR system (347). This occurred in Switzerland, where EHR adoption was slow due to fragmentation and disagreements among stakeholders despite having federal law in place (348). Similarly, the e-tick's adoption was also affected by the provincial health government's decision to select an off the shelf system rather than building on existing systems which are already integrated in district health departments. While the provincial department is within its rights to do this, such competing interests can undermine locally developed systems such as the e-tick. A potential strategy is to support existing local systems while promoting interoperability through standardized formats and exchange protocols (349,350). This can be achieved through a phased approach, beginning with district or regional integration until national level, a strategy that has proven effective in resource limited countries (351).

In South Africa, public health care financing has relied on not only government but also external sources of funding South Africa's digital health landscape has benefited significantly from international donor funding, particularly from agencies such as USAID and the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) (352,353). These funding streams have played a crucial role in supporting digital health infrastructure, including electronic health record (EHR) systems as in the case of the E-tick and other systems such as the TIER.net. However, the cutting of USAID funding to South Africa, as part of the U.S. government's shift toward refocusing their aid priorities, presents a major risk to the sustainability of donor-funded digital health initiatives (354). Furthermore, Canada's experience with EHR implementation offers a cautionary lesson. The country faced a funding freeze that stalled national digital health progress, illustrating the long-term risks of underinvestment and inconsistent policy commitment (324). To lessen the chances of facing similar setbacks, South Africa must prioritize sustainable financing models and long-term investment strategies. This can help to prevent digital health stagnation and ensure continuity in implementation efforts as some districts were heavily dependent on US funding (355).

Conclusion

Given the tensions and trade-offs involved in EHR implementation, evidence shows that a one-size-fits-all approach is unlikely to succeed. Instead, South Africa must adopt a multi-faceted strategy that balances national objectives with local realities, strengthens cross-sector collaboration, and builds capacity while ensuring interoperability. If these challenges are effectively navigated, the country can harness the full potential of EHRs to improve healthcare

delivery, enhance data-driven decision-making, and support its goal of universal health coverage through the national health insurance.

8.4 Contributions to knowledge

This study adds and expands on the existing knowledge on the barriers and facilitators to EHR implementation, offering both global and localized perspectives. Its unique contributions include the following:

Implementation strategies for middle income countries

Many studies that report on EHR implementation focus on high income countries. This study synthesizes global and local evidence to provide insights specific to middle income countries, considering their unique structural, economic and governance challenges in these contexts. The study also highlights and draws lessons from other middle-income countries such as Brazil where resource constraints have led to other innovative solutions such as leveraging open-source software.

The study delves deeper into the complexities of governance in South Africa, identifying the tensions and trade-offs that need to be managed for successful implementation. The federal system further illustrates this issue, showing that while policies are set at national level, provinces and districts differ when it comes to readiness and capacity.

Contributions to theory

This thesis makes contributions to theory in important ways, as it extends the use of CFIR and NPT in a South African context. Both frameworks provided useful lenses for structuring the analysis, but the findings show important areas where their assumptions need adaptation. For example, CFIR's "outer setting" construct is often conceptualised in terms of external incentives and resources. In the South African case, however, the outer setting was strongly mediated by political economy factors, such as donor-driven disease programmes and historically entrenched funding silos. This had a direct bearing on the design and sustainability of digital health interventions as shown in the case study in Chapter 6. Similarly, NPT's construct of "cognitive participation", referring to the work individuals and groups do to build commitment to a new practice, proved insufficient to capture how leadership styles, institutional politics, and resistance from entrenched actors undermined collective ownership. Highlighting these

dynamics brings more attention to the theoretical utility of both frameworks, showing that their application in LMICs requires closer attention to power relations, governance structures, and system fragmentation.

Case study contributions

This study provides real world experiences in South Africa as concrete examples of the practical challenges that affect digital health initiatives such as power outages, lack of funding and support from the provincial health department. Examining this case study also offers strategic considerations for addressing these challenges in the context of South Africa. These findings also raise important questions about how implementation ideas should be applied in LMIC contexts, especially when drawing lessons from high income countries. For instance, much of the literature and theoretical frameworks are often presented as flexible and adaptable, yet their typical use reflects assumptions rooted in high-income health systems. While this may be useful, governance structures in these contexts are more stable, with less severe resource constraints, and less contested power relations. The South African case demonstrates that implementation processes for LMICs must be adapted not only to guide systematic analysis but also to explicitly account for political contestation and system-wide interactions.

8.5 Strengths and limitations

This study has several strengths and limitations worth noting. One of the core strengths is the incorporation of diverse stakeholder perspectives from higher level managers, decision makers to end users from health care facilities. This approach enhances the study's depth by capturing insights from different perspectives and closing information gaps through triangulation. Moreover, the use of theoretical frameworks (CFIR and NPT), strengthens the analysis by grounding it in established theory and enhancing validity and reliability. Lastly, the study integrates local (micro), national (meso) and global (macro) perspectives to provide a well-rounded analysis of factors influencing EHR implementation.

Despite these strengths, some limitations to this study are worth mentioning. First, the rapid review relies on qualitative data only, which although useful in understanding user perceptions, may only lead to reporting of perceived effectiveness instead of measured and quantifiable effectiveness. Moreover, while the review focused primarily on direct user engagement strategies, we acknowledge that broader systemic and governance-level strategies such as

leadership buy-in, policy incentives, and institutional culture, also play a critical role in shaping implementation outcomes. Future research could explore these dimensions more explicitly. Additionally, the limited search scope (PubMed and CINAHL) may have excluded relevant studies from other databases, and the reliance on qualitative data may constrain generalizability. These limitations should be considered when interpreting the findings.

Secondly, the analytic approach in paper 1 allowed themes to emerge inductively rather than framing the findings around a theoretical framework. While the absence of an implementation science framework may not have fundamentally altered the findings, the use one could have provided better structure and comparability of findings with similar studies. This limitation should be viewed in relation to Papers 2 and 3, which explicitly used frameworks (NPT and CFIR), demonstrating the added value of framework guided analysis and situating findings within broader theoretical debates. Moreover, the use of snowball sampling may not guarantee representativeness as participants may have nominated people who likely shared the same views. As such, snowballing may have limited the diversity of perspectives, particularly from underrepresented stakeholder groups such as frontline IT personnel or provincial policymakers. While efforts were made to improve sample diversity by asking for contacts with differing views, this may not have addressed the issue entirely. Future studies could adopt more inclusive sampling strategies to ensure broader stakeholder representation and triangulate findings with quantitative data to enhance generalizability. This limitation relates to methodological trade-offs inherent in qualitative research. Although the study offers context-specific insights, the findings may not be generalizable across all settings. Lastly, the collection of data during the Covid-19 lockdown may have limited the participation, as some health care professionals were not available during this period.

CHAPTER 9: Conclusions and recommendations

9.1 Summary of key findings

This study explored the key barriers and facilitators to implementing EHRs in South Africa. A key finding shows that while South Africa has a well-articulated policy landscape, the implementation of these policies has not been optimal. Beyond policies, the public health sector must address the infrastructure gaps in health facilities, improve the recruitment and retention of skilled professionals, support local initiatives and ensure interoperability of existing systems, to build a robust digital health ecosystem. At a national scale, this requires long term commitment with sustained funding, skills and expertise and strong leadership to lead this vision. At the facility level, user adoption of EHRs is critical and can be strengthened through user engagement strategies to foster collaboration and promote system ownership. Ultimately, successful EHR implementation requires balancing several tensions and trade-offs towards a synergistic approach that integrates top-down and bottom-up solutions.

9.2 Implications for policy and practice

The research findings have practical implications for policy and practice, particularly for South Africa and other middle-income countries as follows:

Policy

Policymakers must ensure that health policies are not only well-developed but also be involved in the development of legal and regulatory frameworks to standardize health data collection procedures for consistency across facilities. Given that South Africa has the Health Normative Standards Framework, policies should go beyond mandating use but also incentivise adoption and use of EHRs. However, with the anticipated growth of EHR adoption in South Africa, policies should also address data security and privacy concerns in accordance with global best practices such as the General Data Protection Regulation (GDPR) (356) or the Health Insurance Portability and Accountability Act (HIPAA) (357). Although South Africa's Protection of Personal Information Act (POPIA) provides a foundation, further refinements may be required to address specific risks that are associated with the use of EHRs at a national scale.

Implementers

Health facility administrators, clinicians, IT teams and managers play an important role in the successful adoption of EHRs. As such, Implementers should draw lessons from health facilities that have successfully implemented EHRs. Many implementation challenges such as staff resistance and lack of infrastructure could be anticipated and addressed proactively. Implementers may also need to use a phased approach for gradual adaptation and to address challenges in real time and find ways to increase ways to increase the sharing of EHR implementation experiences among them. Implementers should also share implementation experiences across facilities through platforms, workshops, online communities and conferences as this could help promote best practices in EHR adoption. For instance, the South African Health Informatics Association (SAHIA) could provide a platform to facilitate knowledge exchange between implementers.

Stakeholders

To ensure successful and sustainable adoption of EHRs, it is essential to foster collaboration between various stakeholders. This includes partnerships between private sector, NGOs, academics, end users and communities. This allows a sharing of expertise, resources and best practices to harness the power of digital health in expanding health coverage as each stakeholder brings unique contributions which can be leveraged. For instance, academic institutions can help to develop tailored training programs for clinicians or end users, while private sector and NGO collaborations can facilitate innovation and scalability issues. Likewise, end users are key informants when designing systems that meet practical needs of clinicians, which can ultimately improve acceptance and adoption rates.

9.3 Recommendations

Several recommendations can be made based on this study's findings and these include the following:

- Implementing EHRs requires implemented to adopt a collaborative approach by integrating top-down policy leadership with grassroots-level engagement. This fosters a middle out approach, one that allows all stakeholders to be involved in building a national electronic health record in South Africa.
- For best practice of EHR adoption in health facilities, end-user engagement should be prioritized through the use of targeted user engagement strategies to ensure that users not

only understand how to use the system but also feel motivated to contribute towards its ongoing use and improvement. A user centred approach can significantly improve the chances of successful adoption and usability of EHRs.

- Building a national EHR will require South Africa to overcome interoperability barriers by developing a robust digital health ecosystem. This includes establishing a national health information exchange that connects different EHR systems using the Health Normative Framework Standards as a model for enabling cross platform data exchange.
- Investing in capacity building is a cornerstone of necessary preparatory measures for a digital health transformation. This can be achieved by addressing skills in digital health and workforce training programs which include health informatics education through academic institutions and professional development programs.
- Securing financial investments to support EHR infrastructure, particularly in underserved areas, is necessary. Besides governments intentionally creating financing models from revenue collected, this can also be achieved by exploring public-private partnerships to finance EHR systems.

9.4 Areas for future research

Future research could expand on quantitatively measuring the impact of engagement strategies on EHR implementation outcomes such as adoption rates, user satisfaction and clinical performance particularly with quantitative research methods. Methodologically, mixed-methods studies combining qualitative insights with quantitative evaluations could be useful in assessing the impact of specific engagement strategies on adoption rates and data quality.

Although such studies have been conducted in high-income countries, there is a need to explore these dynamics in South Africa. More research could explore the effectiveness of systemic and governance-level engagement strategies, such as leadership buy-in, policy incentives, and institutional culture, in shaping EHR implementation outcomes. Policy evaluation studies could also examine the digital health implementation strategies across provinces, identifying factors that enable or hinder scale-up and sustainability or comparative studies between provinces or districts to draw lessons for national integration. Moreover, as the country advances with the National Health Insurance, further research could explore preparatory measures for digital health investments such as digital health infrastructure, data governance and public health surveillance systems supported through EHRs. Lastly, longitudinal studies may be conducted to assess the long-term sustainability and impact of EHRs as well as value for NHI initiatives.

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APPENDICES

Appendix 1: Table of reviews conducted on EHR implementation (2015-2024)

Authors/Year	Type of review	Description (Findings and evidence gap)
Kruse et al. (2016)	Systematic literature review	**Aim:** This review aimed to understand barriers hindering US healthcare organizations from adopting a basic EHR system. **Findings:** The review identified 68 barriers but did not present them in order of significance which include lack of technical support and user resistance. The review highlights the need to address these barriers for policymakers and researchers. **Evidence gap:** The review shows the need for user engagement among other implementation strategies.
Gesulga et al. (2018)	Structured literature review	**Aim:** This review focused on identifying barriers to EHR implementation to inform readiness assessments. **Findings:** User resistance, lack of skills, concerns about return on investment, and lack of administrative and policy support were identified as primary barriers. **Evidence gap:** The review suggests further research is needed to examine these barriers and develop strategies to address them. The review does not explicitly mention user engagement.
Dornan et al. (2019)	Review	**Aim:** This review summarized efforts to implement EHR systems for various uses in Asia, focusing on success factors and challenges. **Findings:** The review highlighted a wide range of contexts, including low- and middle-income settings, diverse organizational structures, and differing levels of technological infrastructure and EHR maturity. Key findings included the importance of standardized patient identifiers, flexible information systems, user-friendly interfaces, and data visualization tools. **Evidence gap:** Limited scope on user targeted interventions.
Alanazi et al. (2020)	Systematic review	**Aim:** This review examined healthcare professionals' perceptions of EHR adoption and use in Gulf Cooperation Council (GCC) countries. **Findings:** Positive perceptions related to improved data access, communication, efficiency, quality of care, patient safety, and reduced costs were found. Challenges included workflow and communication disruptions, inadequate training, high initial costs, and privacy and security concerns. **Evidence gap:** The review shows the lack or poor user engagement from workflow disruptions and poor training.
Fennelly et al. (2020)	Rapid umbrella review	**Aim:** This review aimed to identify key factors impacting the successful implementation of EHRs across different healthcare settings. **Findings:**

		The review identified 15 key factors across organizational, human, and technological domains. The review highlighted the need to consider local context, end-users, and technology advancements. **Evidence gap:** The evidence gap identified is the lack of research on how these factors interact dynamically. While end-user involvement was mentioned, the review doesn't explicitly state if user engagement was part of the included studies.
Tsai et al. (2020)	Scoping review	**Aim:** This review aimed to understand the effects of EHR implementation and barriers to adoption and use. **Findings:** Positive effects included improved efficiency, communication, accessibility, and quality of care. Negative effects included decreased efficiency and dysfunctional workflows. Barriers identified included resource constraints, inadequate training and support, and poor technology literacy and skills. **Evidence gap:** The review shows challenges with user engagement resulting in workflow disruption and inadequate training and support.
Busse et al. (2023)	Scoping review	**Aim:** The review aimed to provide an overview of user involvement methods in EHR development and support the planning of future involvement processes. **Findings:** Physicians and nurses were the most frequently involved groups, often only once. The review found a lack of reporting on co-design approaches and development team competencies. It highlights the need for quality standards in EHR development, user involvement, and consistent reporting in future studies. **Evidence gap:** The review is limited on ways to involve users beyond co-designing and development.

Appendix 2: Ethics approval letter from the University of the Witwatersrand

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

2023/09/04

Mr C Zharima
School of Public Health
Centre for Health Policy
Medical School
University

Sent by e-mail to: campionzharima@gmail.com

Dear Mr Zharima

Re: **Protocol Ref No:** M210213
Protocol Title: *The challenges and strategies to ensure implementation of quality electronic health records in South Africa*
Principal Investigator: Mr C Zharima

Thank you for your e-mail of 2023/08/23.

I confirm that the attached documentation enables us to confirm that Phase 1 of your study is approved unconditionally. I note that the Focus Group Discussions, originally envisaged as Phase 2, are now unlikely to proceed.

Thank you for keeping us informed.

Yours Sincerely

I. Burns
.....
Mr I Burns
For the Human Research Ethics Committee (Medical)

.....
Professor P Ruff, Chairperson, Human Research Ethics Committee (Medical)

Appendix 3: University of Cape Town ethics approval letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room G50- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

07 October 2021

HREC REF: 623/2021

Prof J Goudge
Centre for Health Policy, School of Public Health
University of Witwatersrand
Email: Jane.goudge@gmail.com
Student: 783436@students.wits.ac.za

Dear Prof Goudge

PROJECT TITLE: THE CHALLENGES AND STRATEGIES TO ENSURE THE IMPLEMENTATION OF QUALITY ELECTRNOIC HEALTH RECORDS IN SOUTH AFRICA-PHD CANDIDATE-MR CAMPION ZHARIMA

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020: 06 July 2020 & 01 July 2021.

Approval is granted for one year until the 30 October 2022.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our **website:** www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Mr Campion Zharima will also be involved in this study.

Please quote the HREC REF 623/2021 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Appendix 4: Ekurhuleni district research permission letter

City of Ekurhuleni

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

EKURHULENI HEALTH DISTRICT
RESEARCH PERMISSION

Research Project Title: The challenges and strategies to ensure implementation of quality electronic health records in South Africa.

NHRD No: Not yet applied

Research Project Number: 06/04/2021-07

Name of Researcher(s): Campion Zharima

Division/Institution/Company: University of Witwatersrand

Date of review by the EHDRC: 30 March 2021

DECISION TAKEN BY THE EKURHULENI HEALTH DISTRICT RESEARCH COMMITTEE (EHDRC)

- This document certifies that the above research project has been reviewed by the EHDRC and permission is granted for the researcher(s) to commence with the intended research project.
- Facilities approved for the research: Phillip Moyo CHC, Mary Moodley CHC and Andries Raditsela Clinic.
- Participants' rights and confidentiality must be maintained throughout the study period and when disseminating the findings.
- No resources (financial, material and human resources) from the health facilities will be used for the study. Neither the district nor the health facilities will incur any additional cost for the study.
- The study will comply with Publicly Financed Research and Development Act 2008 (Act 51 of 2008) and its related regulations.

Title: The challenges and strategies to ensure implementation of quality electronic health records in South Africa.

- The EHDRC must be informed in writing before publication or presentation of research findings and a copy of the report/publications/presentation must be submitted to the EHDRC
- The district must be acknowledged in all the reports/publications generated from the research.
- The researcher will be expected to provide the EHDRC with
  - Six monthly progress updates including any adverse events
  - The final study report in electronic format
  - Present the final research findings at the annual Ekurhuleni research conference if possible.
- The EDHRC reserves the right to withdraw the approval, if any of the conditions mentioned above have being breached
- The research committee wishes the researcher(s) the best of success.

Thembani Masina

DEPUTY CHAIRPERSON: CITY OF EKURHULENI

Dated: 14/04/2021.

Dr. Ronel Kellerman

CHAIRPERSON: GAUTENG DEPARTMENT OF HEALTH (EKURHULENI HEALTH DISTRICT)

Dated: 19/04/2021

Appendix 5: Johannesburg district research permission letter

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Joburg
a world class African city

Research Committee of Johannesburg Health District

Enquiries: Prof S. Moosa | 0824466825 (WhatsApp) | shabir@profmoosa.com

DATE: 24th May 2022

ATT: Mr. Campion Zharima

EMAIL: campionzharima@gmail.com

Dear Sir/Madam

STUDY TITLE: The challenges and strategies to ensure implementation of quality electronic health records in South Africa.

NHRD REF. NO.: GP_202204_059

OFFICIAL APPROVAL

The District Research Committee has reviewed your application. This letter serves as a final approval letter for this study.

The following conditions must be observed:

- The facilities in which the research will be conducted are listed below
- These facilities will be visited from: 2022/05/24 to 2026/06/01
- Participants' rights and confidentiality will be maintained all the time.
- Neither the District nor the facility will incur any additional cost for this study.
- No resources (Financial, material and human resources) from the above facilities will be used for the study.
- The study will comply with Publicly Financed Research and Development Act, 2008 (Act 51 of 2008) and its related Regulations.
- You will submit a copy (electronic and hard copy) of your final report. In addition, you will submit an annual progress report to the District Research Committee.
- If this is academic research then your supervisor and the University will ensure that these

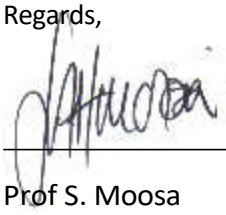
reports are being submitted timeously to the District Research Committee.

- The District must be acknowledged in all the reports/publications generated from the research and a copy of these reports/publications must be submitted to the District Research Committee.
- You will liaise with the manager/s listed below as relevant before initiating the study.

We reserve our right to withdraw our approval, if you breach any of the conditions mentioned above. Please feel free to contact us, if you have any further queries.

On behalf of the District Research Committee, we would like to thank you for choosing our District to conduct such an important study.

Regards,



Prof S. Moosa

Chairperson: District Research Committee
Johannesburg Health District

As delegated by Mrs M.L. Morewane, Chief Director, Johannesburg Health District, and Mr. Frans Moseane, Acting ED Health, City of Johannesburg

Date: 24th May 2022

Appendix 6: Gauteng provincial research permission letter

GAUTENG PROVINCE
HEALTH
REPUBL*C OF SOUTH AFRICA

PERMISSION TO CONDUCT A STUDY WITHIN GDOH CENTRAL OFFICE

Researcher's Name (PI)	Mr. Campion Zharima
Organization I Institution	University Of The Witwatersrand
Research Title	The challenges and strategies to ensure implementation of quality electronic health records in South Africa.
Contact Details	campionzharima@gmail.com +27630636776
NHRD Number	GP 202106 035
Sites	GDOH

Your application to conduct the above mentioned study has been reviewed by the relevant provincial structures and permission has been granted to conduct research at the sites indicated.

You agree to submit a report after completion of your study and present your findings to the Gauteng Health Department.

[X] Permission granted

[ ] Permission denied

Dr. Bridget Ikalafeng

Deputy Director: Research & Epidemiology

Date: 26/01/2021

Appendix 7: National research permission letter

DIRECTOR GENERAL
HEALTH
REPUBLIC OF SOUTH AFRICA
PRETORIA
Private Bag X828, PRETORIA, 0001, Dr AB Xuma Building, 1112 Voortrekker Rd, Pretoria Townlands 351-JR, Pretoria, 0187, Tel (012) 395 8000
CAPE TOWN
P.O. Box 3875, CAPE TOWN, 8000, 103 Parliament Towers, Room 615, Plein Street, CAPE TOWN, 8000 Tel (021) 461 2040 Fax (021) 461 6864

Mr Campion Zharima
School of Public Health
60 York Rd
Parktown,
JOHANNESBURG
2193

Dear Mr Campion Zharima

PERMISSION TO INTERVIEW OFFICIALS OF THE NATIONAL DEPARTMENT OF HEALTH ON IMPLEMENTING ELECTRONIC HEALTH RECORDS IN SOUTH AFRICA

Your application letter dated refers.

1. RESOLUTION AND APPROVAL

It was recently resolved by the Directorate: Health Research in consultation with the affected Units within the National Department of Health (NDoH) that; the request for permission to conduct the study according to the following Protocol be approved:-

Study title: THE CHALLENGES AND STRATEGIES TO ENSURE IMPLEMENTATION OF QUALITY ELECTRONIC HEALTH RECORDS IN SOUTH AFRICA

1.1 BEFORE THE COMMENCEMENT OF THE STUDY

Pease note: Copies of written Research Ethics Committee approval to be submitted to the NDoH before study commences.

2. AUTHORISATION

Authorisation is hereby granted to interview the following officials within the NDoH

- Dr Nicholas Crisp (Deputy Director-General: National Health Insurance)

3. PLEASE FORWARD

It is a requirement that a copy of this letter be forwarded to all the relevant NDoH officials, including the approving Research Ethics Committee(s).

4. THIS AUTHORISATION IS SUBJECT TO THE FOLLOWING CONDITIONS

(a) The NDoH shall be notified of any decision to discontinue the research study. The reason for such cancellation shall be stated.

(b) The research study shall be conducted in accordance with the Protocol submitted to the NDoH. Any Amendment(s) to the protocol, shall first be submitted to the NDoH.

5. PROGRESS REPORT

Submission and presentation of the final report of the study with recommendations to the NDoH is required.

6. INFORMED CONSENT

It is the NDoH requirement that in all research projects the 'Principle of Informed Consent' should be adhered to. This applies to research study volunteers and participants.

Yours sincerely

DR SSS BUTHELEZI
DIRECTOR-GENERAL: HEALTH
DATE: 09.03.22

Appendix 8: Objective 1 participant information sheet

Research Title: **The challenges and strategies to ensure implementation of quality electronic health records in South Africa.**

Good day,

My name is Campion Zharima and I am a PhD candidate at the University of the Witwatersrand, school of Public Health. I would like to invite you to participate in my study titled: **The challenges and strategies to ensure implementation of quality electronic health records in South Africa.** The study examines the implementation challenges and identifies potential strategies to ensure the implementation of high quality electronic health records in South Africa. As part of this, I want to learn more about the readiness of the South African health sector towards the national digital health strategy (2019 – 2024). During the interview, I will ask you about the feasibility of this strategy, the barriers and strategies to implementation and the possible next steps towards the implementation of electronic health records in South Africa.

Should you agree, this will be a face to face interview and we will request for your permission to audio record the interview using an audio recording device. The recordings and transcripts will be kept in a password protected computer. However, my supervisors for this study will have access to the interview data. In a bid to minimize the risk of spreading Covid-19, you are also allowed to opt for a telephonic interview instead of a face to face interview. The interview will take place on a weekday (Monday to Friday) during working hours (8am to 4pm) in a private place that is convenient and comfortable for you, preferably in your work space or office. The interview will last approximately from 45 to 60 minutes and you are only required to answer questions about your experience and knowledge within your profession. There are no risks or any harm associated with your participation in this study and all the information you provide shall be kept confidential. Your identity will also be kept anonymous and no identifying information shall be used in the writing of the report. Direct quotations may be used in writing the report but a pseudonym will be used to protect your identity. Your participation in this study is voluntary and you may choose to not answer certain questions during the interview. You will receive no direct benefits and there will be no compensation or reimbursement for your participation in the study. A summary of the results from this study will be made available upon completion of the study should you wish to see it.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg. A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any questions or need more information about the study, you can contact me via email at campionzharima@gmail.com or my supervisors for this study Prof Jane Goudge (jane.goudge@wits.ac.za) and Prof Frances Griffiths (frances.griffiths@wits.ac.za) for additional inquiries. If you have any questions or need more information about the study, you can contact me via email at campionzharima@gmail.com or my supervisors for this study Prof Jane Goudge (jane.goudge@wits.ac.za) and Prof Frances Griffiths (frances.griffiths@wits.ac.za) for additional inquiries. If you have any concern over the way the study is being conducted, you can contact Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za. Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Yours sincerely,

Campion Zharima

Appendix 9: Objective 1 semi-structured interview guide

Semi structured interview guide for national, provincial DOHs, and districts managers, public health specialists and external stakeholders

1. National Digital Health Strategy 2019 – 2024 and Policy landscape in general
    - Feasibility of strategy and government readiness to support E-health systems
    - Costs of infrastructure, staff training to support this vision
    - Time, willingness and current engagement of government with this initiative
2. Government's current efforts on e-health systems in South Africa
    - current and existing systems (including strengths and weaknesses)
    - National vs Provincial efforts
    - Partnerships with stakeholders such as Academic institutions and Govt bodies
    - weaknesses and strengths of systems
    - use of commercial vs open source
3. Thoughts on the implementation and interoperability of EHRs in South Africa
    - Interoperability of current and existing systems
    - Decision making on procurement (open-source vs licensed)
    - implementation challenges and strategies, recommendations,
    - the next steps towards developing the pathway for implementation of EHR
    - Bottom up/top-down approaches in EHR implementation
4. Thoughts on the National Health Insurance
    - Importance of NHI? Steps moving forward
    - affordable access to health and provision of comprehensive care
    - coordination of health care systems,
    - patient tracking and recording
5. Any additional information (questions, new topics and discussions)
6. Referrals for more participants?

Appendix 10: Objective 2 participant information sheet

Research Title: **The challenges and strategies to ensure implementation of quality electronic health records in South Africa.**

Good day,

My name is Campion Zharima and I am a PhD candidate at the University of the Witwatersrand, school of Public Health. I would like to invite you to participate in my study titled: **The challenges and strategies to ensure implementation of quality electronic health records in South Africa.** The study examines the implementation challenges and identifies potential strategies to ensure the implementation of high quality electronic health records in South Africa. As part of this, I want to learn more about E-tick and its use and I am inviting you to participate in the study as one of the people who use the E-tick system. During the interview, I will ask you about your experiences with the system by looking at the challenges, benefits, data quality and descriptions of how the system can be improved for future use. Your participation will provide valuable insights towards what strategies can be useful in implementing and improving electronic health records in South Africa.

Should you agree, this will be a face to face interview and it will be audio recorded using an audio recording device. The recordings and transcripts will be kept in a password protected computer. However, my supervisors for this study will have access to the interview data.

The interview will last approximately from 45 to 60 minutes and you are only required to answer questions relating to your experience and knowledge within your profession. There are no risks or any harm associated with your participation in this study. All the information you provide shall be kept confidential. Your identity will also be kept anonymous and no identifying information shall be used in the writing of the report. Direct quotations may be used in writing the report but a pseudonym will be used to protect your identity.

Your participation in this study is voluntary and you may choose to not answer certain questions. You will receive no direct benefits and there will be no compensation or reimbursement for your participation in the study.

If you have any questions or need more information about the study, you can contact me via email at campionzharima@gmail.com or my supervisors for this study Prof Jane Goudge (jane.goudge@wits.ac.za) and Prof Frances Griffiths (frances.griffiths@wits.ac.za) for additional inquiries.

Yours sincerely

Campion Zharima

Email: campionzharima@gmail.com

Appendix 11: Objective 2 interview guide for district health managers, implementers and IT personnel

This interview explores managers and implementers' accounts of the development, implementation and maintenance of the E-tick system.

1. Origins and purpose of the E-tick software
    - Development of the software – whose idea and what prompted the development of the software
    - Stakeholder partnerships – support from govt
    - Piloting of system in PHCs – why did you choose those clinics?
2. Implementation of E-tick (devices and choice or change)
    - Consultation and engagement with users with the use of the system with workload
    - Staff training (frequency and the progress) computer skills
    - Support for users – hardware and on-site support IT – Internet issues- dual function
    - Implementation team (who was facilitating?) -
3. Sustainability of E-tick implementation
    - Infrastructure and maintenance such as computers, internet
    - Overall benefits vs challenges
4. Perceived value of the E-tick for health facilities (plans to integrate with other systems, DHIS, HPRS)
    - Integration of E-tick system coordinated/integrated with other systems
    - Data storage, type and quality of data and usability – privacy POPIA
    - link to organisational goals
5. Expansion and further development of the E-tick
    - Challenges and benefits of the system
    - recommendations for improvement (design, completeness and functions)
    - Plans and steps towards further development of software
6. Any insights for implementation of an electronic health record in South Africa drawing lessons from E-tick

Appendix 12: Objective 2 interview guide for end users including clinicians, administrators and data capturers

This interview explores the usefulness of the E-tick system for users, how they integrate it into their daily work patterns and how it integrates with other data systems used in the facilities.

1. Knowledge and use of E-tick
    - nature of work, roles and duties, work experience,
    - familiarity with the E-tick, how long you have used the system, how often you use the system
    - perceived purpose of E-tick system,
    - coordination of system with other users
2. User participation in the use of E-tick
    - Consultation and support for users with the use of the system with workload
    - available routine checks and monitoring systems available for the E-tick system and to help its users
    - Sustainability of system for users
3. Perceived value proposition and usefulness of the E-tick for the organisation

1. Sustainability of E-tick intervention
    - Infrastructure and maintenance such as computers, internet etc
    - Overall benefits vs challenges
    - Engagement with primary users (clinicians and administrators)
    - Staff training and skills development
2. Usefulness of the E-tick intervention to managers
    - Integration of E-tick system coordinated/integrated with other systems
    - Data storage, type and quality of data and usability
    - link to organisational goals
3. Expansion and further development of the E-tick
    - Challenges and benefits of the system
    - recommendations for improvement (design, completeness and functions)
    - issues to consider for expansion of system to other facilities

Appendix 13: Objective 1 and 2 informed consent form for interviews

INTERVIEW CONSENT FORM

Research Title: **The challenges and strategies to ensure implementation of quality electronic health records in South Africa.**

I_____ (insert name) consent to the following:

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

If you have any questions or need more information about the study, you can contact me via email at campionzharima@gmail.com or my supervisors for this study Prof Jane Goudge (jane.goudge@wits.ac.za) and Prof Frances Griffiths (frances.griffiths@wits.ac.za) for additional inquiries. If you have any concern over the way the study is being conducted, you can contact Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za. Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: _____

Date: _____

Signature or mark _____

Name of Researcher: _____

Signature: _____

Date: _____

Appendix 14: Objective 1 and 2 informed consent form for audio recording

AUDIO RECORDING CONSENT FORM

Research Title: **The challenges and strategies to ensure implementation of quality electronic health records in South Africa.**

I _____ (insert name) hereby consent to audio recording of the interview and I understand that:

1. The recording will be stored in a secure location (a locked cupboard or password protected computer) with restricted access to the researcher and the research supervisor.
2. The recording will be transcribed and any information that could identify me will be removed,
3. The recordings will be erased within either (a) two (2) years of the publication of the research findings, or (b) six (6) years, if no publications arise from this research
4. Anyone wishing to access this information in the future will first have to obtain the approval of the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg
5. Direct quotes from my interview, without any information that could identify me, may be cited in the research report or other write-ups of research.

If you have any questions or need more information about the study, you can contact me via email at campionzharima@gmail.com or my supervisors for this study Prof Jane Goudge (jane.goudge@wits.ac.za) and Prof Frances Griffiths (frances.griffiths@wits.ac.za) for additional inquiries. If you have any concern over the way the study is being conducted, you can contact Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za. Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: _____

Date: _____

Signature or mark _____

Name of Researcher: _____

Signature: _____

Date: _____

Appendix 15: Turnitin report

Campion Integrating Narrative-1.docx

ORIGINALITY REPORT

12%	8%	11%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.ncbi.nlm.nih.gov Internet Source	1%
2	formative.jmir.org Internet Source	<1%
3	Wang, Ching-Yu. "Exploring the Perspectives of Emergency Department Nurses on Implementing Social Risk Screening.", The University of Utah Publication	<1%
4	doaj.org Internet Source	<1%
5	www.researchsquare.com Internet Source	<1%
6	Girdhari, Shaivar. "A Framework for the Adoption of Blockchain to Enhance the Implementation of the National Health Insurance.", University of Johannesburg (South Africa), 2024 Publication	<1%
	worldwidescience.org	